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STUDIES IN ENTOMOGENOUS FUNGI.

THE NECTRIAE PARASITIC ON SCALE INSECTS.

(continued from p. 132)

By T. Petch, B.A., B.Sc.

NECTRIA.

Nectria diploa B. and C.

This species was described by Berkeley and Curtis in Jour. Linn. Soc. x (1868), p. 378, as "Caespitosa; peritheciis aurantiacis furfuraceis; sporidiis biseriatis fusiformibus, 2–4 nucleatis (606). On bark. Hab. Car. Inf., No. 4029. Sporidia ·0012–·001 inch long, ·00035 wide." The specimens were from Cuba, and, as explained by Berkeley, in the introduction to Fungi Cubenses, the places cited under "Habitat" are extra-Cuban localities from which he believed he had the same species.

The type in Herb. Kew is marked 606; it is a caespitose *Nectria*, on a scale insect, apparently *Aspidiotus*, and has a *Pseudomicrocera* conidial stage. Specimens distributed in Fungi Cubenses Wrightiani, No. 767, are the same species, as regards the examples in Herb. Kew and Herb. British Museum. Von Höhnel (in Herb. Kew) states that *Nectria diploa* B. and C. is the same as *Nectria laeticolor* B. and C., but that is not the case.

The specimens from South Carolina, No. 4029, are a totally different species. These were subsequently described by Berkeley (Grevillea, iv (1875), p. 46) as *Nectria diploa* B. and C. var. *minuta*, on some *Sphaeria* on alder, Car. Inf., No. 4029, but they have no relationship or resemblance to the Cuban species. The perithecia are minute, conical, about 160 μ high and 120–200 μ diameter, blood red, smooth, translucent, collapsing laterally, with a papillate apex; the asci are sessile, narrow oval, about 70 × 12 μ, and the ascospores oval or subcymbiform, 22–24 × 8–10 μ. According to von Höhnel in Herb. Kew, this is the same as *Nectria guaranitica* Speg. There are specimens in Herb. British Museum, "*Nectria diploa* B. and C., 55, ad corticem *Alni*," marked by Broome "Ravenel, (spore) about 0·0012 inch long," with a drawing of the spore; "*Nectria diploa* B. and C., Cort. Alni, Society Hill, S.C., M.A.C.," with drawing of spore "·001 inch long"; and "*Nectria diploa* B. and C., coll. M. A. Curtis, Distrib. W. G. Farlow"; while Herb. Kew has "4029, on *Alnus*, Car. Inf." All these appear to be the same, but not *Nectria diploa*. This species is parasitic on lichens or *Pyrenomycetae*.

Seaver (Mycologia, i, p. 190) places *Nectria diploa* in *Creo-*

nectria, and states that it is only known from the type locality, South Carolina. He cites Ravenel, Fungi Car. Exsicc., No. 55. It is evident that this refers not to *Nectria diploa* but to the Carolina species which Berkeley confused with it.

Nectria diploa has been collected in Ceylon on two occasions—on *Fiorinia rubrolineata* on *Murraya exotica*, Peradeniya, and on *Lepidosaphes* sp. on an undetermined plant, Kandy. I have also a specimen of *Pseudomicrocera* on *Fiorinia fioriniae* on *Camellia* from Mauritius, which bears immature perithecia, apparently of this species.

The perithecia are situated on the old conidial stroma (Plate III, fig. 13), which forms a narrow, compact, pink border round the scale, with a narrow, white, byssoid margin, or sometimes a broader, scarious margin. In the available specimens, effete *Pseudomicrocera* sporodochia, either horizontal or oblique, are present. The perithecia are scattered, or clustered in groups up to six; they are globose or slightly ovoid, up to 0·4 mm. diameter, bright red, with a darker red ostiolum. In old herbarium specimens, the perithecia become orange-red or orange-yellow. They bear a few large warts, up to 0·1 mm. high, which are sometimes confluent and form a continuous crust except round the ostiolum. These warts are composed of oval, or globose, rather thick-walled cells, 7–13 × 7–12 μ. The asci are clavate, sessile, either four-spored, 64–68 × 12 μ, or eight-spored, 96–116 × 10–14 μ, both being found in the same specimen. The ascospores (Plate V, fig. 22) are pale yellow, at first pluriguttulate, then one-septate, not constricted, ends obtuse, elliptic, narrow-oval, or subcymbiform, 16–32 × 6–9 μ. Berkeley's measurement of the ascospore was 25–30 × 9 μ.

This species was described by Spegazzini as *Nectria coccorum* in Fungi Guaranitici, Pugillus 1, No. 234, and as *Nectria coccogena* in Fungi Puiggariani, No. 289. Prof. Spegazzini has kindly submitted for examination his specimens of these and other coccid Nectriae.

Nectria coccorum is represented in Herb. Spegazzini by the type, No. 3867, on fallen leaves of some *Laurineae*, Peribebuy, Brazil, July 1883, and No. 4046, Paraguay, November 1883. Both the specimens show a *Pseudomicrocera* conidial stage, with typical conidia, 60–78 × 4 μ. The surface of the stroma in the type is rather more tomentose than in the Eastern forms, or in other American specimens but that may be due to the fact that the specimens occurred on fallen leaves. The perithecia are superficial on the stroma, either isolated or two or three together: they are about 0·2 mm. diameter, covered with warts composed of large cells, or pruinose, with a continuous layer of the same cells.

Unfortunately, all the specimens of *Nectria coccorum* appear to be too immature to show recognisable ascospores. Spegazzini described the ascospore as cylindrico-fusoid or elongated elliptical, "utrinque obtuse acutatis," 22–25 × 5 μ, one-septate, not or slightly constricted, hyaline, and the herbarium specimens bear figures which show them as fusoid, constricted or not at the septum, with obtuse, acuminate ends. I was able to find one spore of this character (16 × 5 μ), but it was pale brown. It would seem probable that these spores are intrusive, and belong to some Sphaeriaceous fungus, not to the *Nectria*.

The type of *Nectria coccogena* is No. 2338 in Herb. Spegazzini, on leaves of a *Eugenia*, near Apiahy, Brazil. Its *Pseudomicrocera* conidia measure 82–96 × 4–5 μ. The perithecia are scattered or clustered, up to 0·4 mm. diameter, covered with large, irregular warts. The ascospores are elliptic to narrow-oval, sometimes subcymbiform, ends obtuse, one-septate, not constricted, thick-walled, yellowish, 16–24 × 6–9 μ (Plate V, fig. 18). In the original description of *Nectria coccogena*, the perithecia were said to be at first covered with a cottony hyaline pruina; it is possible that this may refer to the tip of the sporodochium, its base having been mistaken for a developing perithecium. The difference in size of the perithecia of *Nectria coccorum* and *Nectria coccogena*, may be partly due to the fact that the former is immature, but it is chiefly owing to the greater development of the warts in the latter species. It is not possible to separate these two on the available material.

The variation in the size and shape of the ascospores is remarkable. In the Ceylon examples, most of the ascospores are narrow-oval or subcymbiform, 22–32 × 7–8 μ, only a few being elliptic and 16 × 7–8 μ. In *Nectria coccogena*, type, the variation of the ascospore was from 16 × 8 μ to 24 × 7 μ in the one perithecium; many asci contained only elliptic spores, and the longer spores were slightly broader (in proportion) and less decidedly cymbiform than in the Ceylon form.

"*Nectria coccorum* Speg., Balansa, Pl. de Paraguay, 4046, Nov. 1883" in Herb. Kew, is *Nectria diploa*. This is apparently the same collection as "*Nectria coccorum* Speg., No. 4046, Paraguay, Nov. 1883" is Herb. Spegazzini. It is also represented in Herb. Kew by "3547, Roumeguère, Fungi Gallici Exsiccati, *Microcera coccophila* Desm., on coccus on leaves of *Myrtaceae*, Paraguay, Sept. 1883 (J. Balansa 4046)," which is *Pseudomicrocera Henningsii* with well-developed *Nectria diploa*. "Roumeguère, Fungi Selecti Exsiccati, No. 5229, on a coccus on leaves of *Pilocarpus pinnatus*, Paraguay, Coll. Balansa," issued as *Nectria coccorum* Speg., is also *Nectria diploa*, and the same is true of "*Nectria oidioides* Speg., *myrticola* Rehm on

Eugenia sp. Blumenau, Nov. 1888, Ule, Herb. Brasiliense, No. 1288"; for both these, the examples in Herb. Kew have been examined.

In Herb. British Museum, there are specimens of *Pseudomicrocera Henningsii* from Florida communicated by E. W. Berger under the name *Sphaerostilbe coccophila*. One collection, on Florida red scale of citrus (*Chrysomphalus aonidium*), contains eight leaves, six of which bear *Pseudomicrocera Henningsii* and two, *Microcera aurantiicola*. Another, on purple scale of citrus (*Lepidosaphes beckii*), consisting of six specimens, is *Pseudomicrocera Henningsii*, except as regards one specimen which is *Microcera aurantiicola*.

Other specimens of *Pseudomicrocera Henningsii* have been referred to under *Pseudomicrocera*.

Nectria coccophila Nomura.

This species, described by Nomura in 1901, was found by him on *Aspidiotus perniciosus* on *Pyrus sinensis*, and *Diaspis pentagona* on *Morus alba*, in Honsui, Japan. Miyabe and Sawada were apparently unacquainted with it, but cite Nomura's description, as follows.

Sporodochia irregularly pulvinate, not stilboid, orange-red, on a reddish stroma, sometimes confluent. Conidia falcate, of the *Fusarium* type, three- to five-septate, reaching 100 μ in length. Perithecia flask-shaped, bright red, appearing on the outer surface of the scale, three to four in a group, 260–340 μ high, 240–320 μ broad. Asci fusiform, obtusely pointed at the apex, 90–110 $\times$ 8–10 μ, eight-spored, spores uniseriate, more or less oblique. Spores light brown, one-septate, slightly constricted at the septum, 15–20 $\times$ 5–6 μ. Stroma scarlet, sclerotioid in texture.

Nomura compared his species with Rolf's figures of *Sphaerostilbe coccophila*, and came to the conclusion that the Japanese and Florida species were the same, but that neither was *Sphaerostilbe coccophila* Tul. This, however, does not afford much assistance in deciding what his species was, for Florida writers have confused *Microcera* and *Pseudomicrocera*, and some of Rolf's figures appear to belong to the latter. Nomura stated that the sporodochia of his species were not stilboid, but irregular protuberances of the type of *Tubercularia*; this again does not help, because in all these species the base of the conidial stage may be reduced almost to vanishing point.

Miyabe and Sawada would appear to incline to the view that *Nectria coccophila* Nomura is identical with *Sphaerostilbe coccidophthora* Zimm. The dimensions of the ascospores are too large for *Sphaerostilbe flammea* or *Sphaerostilbe aurantiicola*, and would agree better with that determination. But the statement

that the sporodochia are seated on a reddish stroma, and that the stroma is scarlet and sclerotioid, points rather to *Nectria diploa*. The description of the conidia as falcate, and three- to five-septate also indicates *Nectria diploa*, and had the breadth of the conidia been given, the description would have been decisive. *Nectria diploa* has coloured ascospores, though they are yellow rather than brown, and the dimensions given are near those of its smaller ascospores. Consequently, if there is no other way of deciding what this species was except by guessing from the description, I should conclude that it was *Nectria diploa*. Judging from the available collections, the perithecia of *Nectria diploa* are much rarer than those of the various species of *Sphaerostilbe* found on scale insects.

A conidial specimen kindly forwarded to me under this name by Prof. Hara, collected on *Aspidiotus* on *Pyrus*, Shizuoka, June 20, 1919, is *Sphaerostilbe aurantiicola* (B. and Br.). The synnemata are pulvinate, but a few are very shortly stalked. The conidia are almost straight with falcate tips, and multi-septate.

Nectria variabilis Hara.

This species was found on a Coccid on *Sasa paniculata* in the Gifu Prefecture, Japan. I have not been able to examine a specimen.

According to the original description, the sporodochia are erumpent (*sic*), irregular, orange-red or rose-coloured, mostly one to two, rarely three, on a scale, 0·5–1 mm. diameter. The conidiophores are filiform, septate, branched at the base, 2·5–3 μ diameter. The conidia are fusariiform, three- to five-septate, 60–70 × 5–6 μ; and filiform paraphyses, hyaline, septate, 2–2·5 μ diameter are present. The perithecia are produced at the base of the sporodochia or on a stroma, and are globose or elliptic, with a papillate ostiolum, solitary or clustered, smooth, carinous (*sic*) membranaceous, orange-red, 270–300 μ diameter. The asci are cylindrico-clavate, apex rounded, stipitate, eight-spored, 130–150 × 11–13 μ, accompanied by filiform paraphyses, 1–1·5 μ thick. The ascospores are uniseriate, fusiform or elliptical, one-septate, slightly or not constricted, 16–22 × 6–9 μ, hyaline or yellow.

Hara's figures show conidia slightly but regularly curved, and ascospores narrow-oval to subcymbiform. His figure of the whole fungus is unrecognisable. From his figures and description of the conidia, they belong to *Pseudomicrocera Henningsii*, though the breadth is rather too large. The ascospores described and figured are those of *Nectria diploa*, but the description of the perithecium does not fit. The balance of evidence is in favour of the supposition that this species also is *Nectria diploa* B. and C.

Nectria Tuberculariae Petch.

A *Nectria* which does not appear to have been previously described has been found on *Lepidosaphes* sp., on orange, in Ceylon. It occurred in company with *Nectria aurantiicola* B. and Br., *Ophionectria coccicola* E. and E., and *Septobasidium rameale* (Berk.), on a tree which had been imported from West Australia five years before.

The perithecia are situated on the scale, or on a thin, white, byssoid stroma, which envelops the scale and spreads out over the leaf. The entire stroma can readily be detached from the leaf, and then presents a smooth, white, under surface, as in *Ophionectria coccicola*. The margin of the stroma is fimbriate.

The perithecia are scattered or clustered, up to 0·2 mm. diameter, globose, with a very minute, conical ostiolum, pale flesh-coloured, with a white pruina (Plate IV, fig. 8). The wall of the perithecium is obscurely parenchymatous, of small cells, and villous with short, spreading, hyaline hairs. The asci are cylindric, eight-spored, spores obliquely uniseriate, 50–62 × 6 μ, furnished with paraphyses which soon disappear. The ascospores (Plate V, fig. 9) are oval, or oblong oval, one-septate, not constricted, hyaline, minutely warted, 6–9 × 4–5 μ. A number of globose spores, about 4 μ diameter, are present: these appear to be aborted ascospores, not part-spores.

With these, on similar stromata, there occurs a *Tuberculariа* conidial form. The sporodochia are variable. In the larger forms (Plate IV, figs. 5, 6) they are flattened pulvinate, compact, oval, or circular, up to 1 mm. long and 0·6 mm. broad, situated at the edge of the scale, and often confluent so as to hide it completely. In other cases the stroma bears small scattered patches of conidia which are barely elevated. The sporodochia are at first pink, with a whitish margin, and minutely pruinose, but, when covered with the spores, they are uniformly pink, or inclining to orange red when moist, waxy, without any evident margin. The byssoid stroma of the conidial stage usually spreads further over the leaf than that of the perithecial stage, and, at its outer edge, one often finds somewhat loose, pinkish tufts of hyphae which are evidently the early stages of other sporodochia. This running habit is especially well-marked, where the *Tuberculariа* is in company with a *Septobasidium* which has developed its bristles. The hyphae of the *Tuberculariа* then ascend the bristles, and form minute pink sporodochia at the apices. The bases of the larger stromata are plectenchymatous. The conidiophores are branched at about one-third of their height, and the branches are clustered, about 30 μ high, 2 μ diameter below, tapering to the apex. The spores are cylindric

with rounded ends, up to 6 × 2·5 μ, or oval, 3–5 × 2–3 μ, or globose 2·5 μ diameter, hyaline, continuous.

This conidial form appears to be identical with *Tuberculariacoccicola* Stevenson, which was found on *Lepidosaphes beckii* and *Hemichionaspis minor*, on *Citrus*, in Porto Rico, in company with *Ophionectria coccicola*, and species identified as *Sphaerostilbe coccophila* and *Microcera Fujikuroi*.

Tuberculariacoccicola was described as having scattered, or clustered sporodochia, superficial, pulvinate, compact, from 0·5–4 mm., averaging 1–2 mm., sometimes uniting irregularly, grenadine pink to safrano pink (Ridgway), fading to dull white with age; margin regular, not setose; conidiophores hyaline, septate, 15–36 μ long, 1·5 μ diameter; conidia forming dense masses on the sporodochia, pink in mass, hyaline by transmitted light, ovoid to cylindric, not guttulate, 2–4 × 1·5–2 μ.

Mr Stevenson has kindly forwarded me a specimen of *Tuberculariacoccicola*, on *Lepidosaphes beckii* on *Citrus decumana*, Espinosa, Porto Rico, March 1917 (No. 6366, Insular Experiment Station, Porto Rico). The individual sporodochia are usually small, but they may be confluent in large masses; they are flattened-pulvinate, circular or oval, usually somewhat pruinose in the dry specimens, but sometimes waxy. The conidiophore is the same as in the Ceylon form, and there is the same mixture of narrow-oval and globose spores. In general, the sporodochia lack the byssoid stroma which is so prominent in the Ceylon form. A slight development of the stroma is however present in some cases, and it would appear probable that the difference between the Ceylon and Porto Rican forms in this respect may be a climatic effect. The two forms are too close to be separated as conidial stages of different fungi, though, when the difficulty of differentiating between other conidial forms of fungi found on scale insects is borne in mind, it must be admitted that the discovery of the *Nectria* of the Porto Rican fungus might demonstrate that they are not identical.

A specimen from South India differs in some respects from the type. It was collected on the Western slope of the Nilgiris, October 1910, on the stems of a small bamboo (indet.), associated with an *Asterolecanium*. Only two sporodochia are present. The sporodochia are superficial, circular, up to 2·5 mm. diameter, flat, thin, with a definite edge; there is no spreading mycelium. The base of the sporodochium is somewhat lax, composed of loosely interwoven, slender, hyaline hyphae up to 2 μ diameter; the upper portion consists of a definite continuous layer of erect conidiophores. The conidiophores are short, about 12 μ high, simple, with conidia, narrow-oval, hyaline, 2–4 × 1·5–2 μ. The colour of the stroma is now white.

One of the sporodochia described above bears a few perithecia partly embedded in it, and crowded together at the edge. The other bears similar perithecia, somewhat crowded, situated all over the sporodochium, and embedded in it. The available specimens have been pressed; in them, the upper part of the perithecium does not project above the sporodochium, but it would appear probable that in a natural condition the perithecia projected for about one-third their height. The perithecia agree exactly with those of *Nectria Tubercullariae*: the ascospores are narrower, 6–8 × 2·5–3 μ, but they are immature.

This specimen differs from the type in the absence of the byssoid stroma which is so noticeable in the former collection, and in the development of the perithecia in the old sporodochia. But it is too close to be separated on the present material.

Nectria barbata n.sp.

An undescribed species of *Nectria* was found on *Lepidosaphes* sp. on *Citrus aurantium*, Glenugie, Ceylon, March 1919.

The perithecia are scattered over the scale, without any stroma, sometimes with a slight basal weft of hyphae. They are conoid or subglobose, about 0·2 mm. diameter, and 0·3 mm. high, collapsing, minutely rugose, yellow-brown or dark amber, subtranslucent (Plate III, fig. 14). The ostiolum is broadly papillate or obtusely conical, and is surrounded, at a short distance below, by a varying number of erect, white, rigid hairs, arranged more or less in a ring. These hairs (Plate V, fig. 4) are up to 50 μ high, 4 μ diameter below, equal, or slightly inflated at the obtuse tip. The perithecial wall consists of an outer, brown, collapsed or amorphous layer which splits into irregular patches, and an inner, hyaline, membranous wall composed of moderately large cells. The asci are cylindrico-clavate, eight-spored, 66 × 6–8 μ, with spores uniseriate, or obliquely uniseriate, or sometimes transverse (Plate V, fig. 5). The spores (Plate V, fig. 6) are hyaline, oblong-oval, ends broadly rounded, one-septate, strongly constricted, 6–8 × 3–5 μ.

I name this species *Nectria barbata*. Its conidial stage has not been observed.

LISEA.

Lisea Parlatoriae Zimm.

This species was described from specimens on *Parlatoria zizyphi* Luc., on *Citrus* leaves, found at Buitenzorg, Java.

The perithecia are crowded, superficial, globose with a papillate ostiolum, 0·2–0·25 mm. high, and 0·15–0·18 mm. diameter, appearing black. By transmitted light, the colour of the perithecial wall is dark violet to black, becoming red-violet on

heating with chloral hydrate. The asci are cylindric and eight-spored, without paraphyses. The ascospores are elliptic, obtuse, one-septate, not constricted, hyaline or slightly brownish, 9–12 × 4·5 μ.

The above details are taken from Zimmermann's description. No specimens of *Lisea* on scale insects have come under my notice.

CALONECTRIA.

Calonectria coccidophaga Petch.

This species, specimens of which were kindly submitted to me by Mr C. C. Brittlebank, occurred on *Planchoma acaciae*, on *Acacia* sp. at Warburton, Victoria, April 30, 1917 (Coll. J. Farrell).

The perithecia are clustered, in pulvinate groups up to 2 mm. diameter, on a fairly well-developed parenchymatous stroma (Plate IV, figs. 3, 4). The cluster appears black, but on detaching the perithecia, they are found to be black in the upper part, but pinkish-yellow below, and the stroma is yellowish. From the colour of the perithecium when immersed in water, it is probably very dark red when fresh. The perithecia are globose, about 0·4 mm. diameter, pruinose, naked at the apex. In some specimens, the apex is papillate, but in other examples it is flat and discoid with a punctiform ostiolum. The wall in section, and internally, is rose-red (Plate IV, fig. 3); it is very thick, and when mounted the outer layer is vinous or purplish-red while the inner layers are yellowish-white. It has a somewhat horny appearance in the dry specimens. The asci are clavate, eight-spored, with spores biseriate above, uniseriate below, 120–140 × 14–16 μ, and are accompanied by stout paraphyses, branched above, with granular contents. The spores (Plate V, fig. 7) are oblong-oval or subcymbiform, straight or curved, with obtuse ends, three-septate, sometimes constricted at the septa, especially at the median septum, 22–34 × 8–9 μ. Occasionally a spore is four-septate, one-half being two-septate. Immature spores in the ascus, though with developed septa, may be fusoid and only 5 μ broad.

With the foregoing, there occurred a conidial stage which is undoubtedly *Microcera tasmanicnsis* McAlp. Mr Brittlebank has kindly submitted to me the type of *Microcera tasmanicnsis* McAlp., on a scale on *Eucalyptus*, Tasmania (A. M. Lea), Aug. 8, 1901, and that of *Microcera Mytilaspis* McAlp., on *Mytilaspis* sp., on *Hymenanthera dentata*, Ivanhoe, Victoria, Sept. 14, 1903. On comparison, it appears that these two species are identical, the first being a younger development of the second. The type of *Microcera Mytilaspis*, though at first sight different from

Microcera tasmaniensis, contains examples which exactly match the latter and their structure leaves no doubt as to their identity. It is not *Microcera* of Desmazières.

The conidial fructifications arise either from a narrow, rather loose weft of hyphae, round or at one side of the scale, or from the hyphae which permeate the scale, without any external stroma. The smaller examples (Plate IV, fig. 2), which constitute *Microcera tasmaniensis*, are clustered, sessile, pulvinate, or subglobose, up to 0·3 mm. diameter, or sometimes discoid. In the dry specimens, they are white and longitudinally tomentose externally, and yellowish and subtranslucent in the centre, but when fresh, they are salmon pink (*fide* McAlpine). The more recent specimens on *Planchoma* retain the pink colour in the centre. The outer layers are composed of parallel hyphae, 4 μ diameter, rather closely septate, running uniformly from base to apex: they form a wall, several hyphae thick, which sometimes projects above the central disc. The central disc consists of close-packed conidiophores, bearing three-septate, fusarioid spores. The internal tissue of the sporodochium, beneath the disc, is parenchymatous. The conidia (Plate V, fig. 13) are slightly falcate, or almost straight, ends obtuse, 44–58 × 5–6 μ. The majority are three-septate, but four- and five-septate examples have been observed.

In the type of *Microcera Mytilaspis* some of the sporodochia answer to the above description, but the majority are larger and more fully developed (Plate IV, fig. 1). The latter are distinctly discoid, usually oval in plan, up to 0·8 mm. long and 0·6 mm. broad, either sessile on the marginal stroma, or shortly stalked. The upper surface is concave, and the outer wall of parallel hyphae is continued well above the disc and strongly incurved. The specimens have exactly the appearance of a *Peziza*. In the shallower sessile specimens, the tissue underlying the disc is small-celled parenchymatous, but in the stalked forms, the cells in the centre are arranged more or less in longitudinal parallel rows. In the latter case, however, they are 4–6 μ broad, septate at fairly close intervals (10–20 μ), with the segments somewhat inflated; the stalk is not composed of long, slender, uniform hyphae as in *Microcera*. The conidia in *Microcera Mytilaspis* are of the same type as in *Microcera tasmaniensis*, and measure 44–54 × 5–6 μ.

In the sporodochia found with the *Calonectria*, the conidia are 30–36 × 4–5 μ, three-septate, occasionally four-septate, almost straight, or curved, or straight with falcate tips, ends obtuse.

A few conidiophores at the margin of the disc may be up to 100 μ long, unbranched, and bear conidia laterally and terminally. The conidiophores in the disc are usually short, re-

peatedly branched, with short, slightly inflated segments, and conidia terminal. The type of branching is fusarioid.

This type of fructification resembles *Pseudomicrocera* in form and in its parenchymatous base, though its general appearance is different owing to the more obvious development of the disc. It differs from *Pseudomicrocera*, however, in the type of conidiophore, and in the continuous wall of parallel hyphae which forms the outer layer of the whole sporodochium. It is a *Fusarium*, with the general shape of a *Peziza*. I propose to call this *Disco-fusarium*.

Disco-fusarium gen. nov. *Tuberculariaceae*. Sporodochium discoid, sessile or shortly stalked, the external layers composed of parallel hyphae, continuous from the base, extending above the disc and forming an incurved margin; disc composed of branched conidiophores; conidia hyaline, fusarioid, multiseptate.

Disco-fusarium tasmaniense (McAlp.); *Microcera tasmaniensis* McAlp., Agric. Jour. Victoria, II (1904), pp. 646–648; *Microcera Mytilaspis* McAlp., *loc. cit.*

There are specimens of *Disco-fusarium tasmaniense* in Herb. Kew, in the cover of *Microcera coccophila*, labelled "On *Acacia*, Grampians, V.," which presumably were from Victoria.

PODONECTRIA.

A *Nectria* with long, septate spores, parasitic on scale insects on orange trees in Florida, was described by Ellis and Everhart in 1886 as *Nectria coccicola*. They stated that it belonged to the subgenus *Ophionectria*, and subsequent references to it have, until recently, employed the latter name.

A similar fungus was found by Zimmermann in Java on *Parlatoria zizyphi* on *Citrus*, and was regarded by him as the same species. He also described the conidial form, which was not recorded by Ellis and Everhart.

The perithecia (Plate IV, fig. 9) are pale to dark brown, thick-walled, with thick-walled asci, which are furnished with paraphyses, and contain long, clavate, septate spores, 100–120 μ long. The conidial stage (Plate IV, fig. 9) is strikingly different from that of other species of *Nectria*; it consists of a short parenchymatous column, which bears at the apex a white, conical head of conidia. The conidia (Plate V, figs. 1–3) are long and septate; they are borne, usually in threes, at the apex of the conidiophores, and they remain united together at the base when detached from the conidiophores. The number in a detached cluster varies, however, from three to five.

In 1913, Miyabe and Sawada recorded *Ophionectria coccicola* from Formosa, where it occurred on *Parlatoria zizyphi* (Lucas) Sign., *Aspidiotus ficus* Comst., *Mytilaspis gloverii* (Pack.) Comst.,

and *Mytilaspis citricola* (Pack.) Comst., on *Citrus nobilis* Lour. They also described a new species, *Ophionectria tetraspora* Miyabe and Sawada, which differed from *Ophionectria coccicola* in having conidia with acute or obtuse tips, usually in fours, and ascospores, 50–64 × 6·5–7·5 μ.

Meanwhile, Seaver, in 1909, had transferred Ellis and Everhart's species to a new genus, *Scoleconectria*. The latter genus contains species provided with a stroma, and having spores from three- to many-septate. It thus includes species which were formerly referred to *Ophionectria* and *Calonectria*, the common distinguishing character being the presence of a stroma. Seaver describes the stroma of *Ophionectria coccicola* as rounded, more or less prominent, whitish. The fungus forms a thin, white, byssoid layer, which spreads out from the scale over the leaf, or stem, in a more or less circular patch, if the scales are far enough apart to permit it to develop without interference. This layer becomes brownish, and the hyphae fuse together, in part, into a membranous sheet, which separates readily from the leaf. The perithecia and sporodochia are produced on this sheet, often at some distance from the scale insect. Where the scale insects are crowded, the thin sheet of hyphae grows over them and binds them together.

Of course, the hyphae of the fungus also penetrate the body of the scale insect, and the central part of the stroma is slightly elevated by the presence of the latter within it; but elsewhere the stroma is thin, flat, and membranous.

The practicability of separating species of *Nectria* into genera, according to the presence or absence of a stroma, has been questioned by other mycologists. But if that basis of division is followed, it would seem preferable to restrict the term stroma, in that application, to the parenchymatous forms. If the term is used to include any basal layer of hyphae, the classification becomes unworkable. *Ophionectria coccicola* does not possess a stroma in the sense that *Nectria cinnabarina* does.

Seaver's separation of *Scoleconectria* from *Ophionectria*, on account of the presence of a stroma in the former, cannot stand if such a basal layer as that of *Ophionectria coccicola* constitutes a stroma. For, as previously stated (Ann. Perad., v, p. 285), in the type species of the genus *Ophionectria*, *Ophionectria trichospora* (B. and Br.) Sacc., the perithecia are seated on a thin, byssoid layer, which is just as good a stroma as that of *Ophionectria coccicola*. Therefore, the original genus *Ophionectria* is stromatic, in the sense in which the writer understands Seaver to employ that term, and the separation of *Scoleconectria* as a stromatic *Ophionectria* is based on a misunderstanding of the nature of the type species of the genus *Ophionectria*.

Von Höhnel has raised objections to Seaver's genus *Scoleconectria* on other grounds. In 1902, Hennings instituted the genus *Tetracrium* for a conidial fungus found on scale insects on the leaves of orange in Brazil. Von Höhnel has examined the type specimen, and finds that this is identical in structure with the conidial stage of *Ophionectria coccicola* (Fragmente zur Mykologie, XIII, p. 27). Hennings' species was named *Tetracrium Aurantii*, and von Höhnel names the conidial form of *Ophionectria coccicola*, *Tetracrium coccicola*. But von Höhnel found perithecia of the same character as *Ophionectria coccicola* in the type specimen of *Tetracrium Aurantii*, and these he regards as belonging to the genus *Puttemansia* Henn. (1902).

According to von Höhnel, *Scoleconectria* is equivalent to *Puttemansia*, both being *Ophionectria* provided with a stroma. This again overlooks the fact that the type species of the genus *Ophionectria* has a stroma.

Puttemansia was described by Hennings as a genus of *Discomycetae*, the type species being *Puttemansia lanosa*. The type specimen has been re-examined by von Höhnel, who stated in his first communication on the subject (Fragmente zur Mykologie, XII, p. 23) that it was a stromatic *Calonectria*, and equivalent to *Scoleconectria* Seaver, the latter genus including species with long, multiseptate spores, and others with elliptic, three-septate spores.

According to von Höhnel (*loc. cit*), *Puttemansia lanosa* builds a parenchymatous stroma within the leaf, which bursts through the epidermis, and forms a superficial, white, external stroma, on which the perithecia are produced. The perithecia are oval, or almost pyriform, 200–280 μ high, 350–420 μ broad, generally immersed in the stroma to one-third, or one-half, their height, and often fused together laterally. The superficial stroma is parenchymatous. The perithecial wall is 40–60 μ thick, rough with projecting groups of cells, and clothed with a woolly covering of thick-walled, septate, obtuse hairs, 300–500 μ long and 5–6·5 μ diameter.

Hennings stated that the stromata were "villo albo omnino tectis," and described the hairs of the perithecial wall as rigid, simple, hyaline, septate, obtuse at the apex, 200–400 × 5–6 μ. The asci were clavate, apex rounded and obtuse, thick-walled, 120–140 × 18–20 μ, furnished with filiform, branched, paraphyses. The spores were oblongo-fusoid, three-septate, 40–50 × 7–8 μ, with a curved basal appendage, 15–20 × 3 μ.

Von Höhnel states that there may be an appendage at one or both ends, but that these appendages are hollow continuations of the end cells, not solid ciliae as in *Paranectria*.

The perithecia found by von Höhnel on the type specimen

of *Tetracrium Aurantii* were named by him *Puttemansia Aurantii* (Fragmente, XIII, p. 28). His description will be quoted later. There can be no doubt that this species is co-generic with *Ophionectria coccicola*, but from the available data it would seem very doubtful whether it is co-generic with *Puttemansia lanosa*. The shape of the spore in the type species of *Puttemansia* is quite different from that in *Ophionectria coccicola*.

The species of *Ophionectria* which are parasitic on scale insects form a natural group, agreeing with one another in having thick-walled asci, long, multiseptate ascospores, and a *Tetracrium* conidial stage. I therefore propose for them a new genus *Podonectria*, the type species being *Podonectria coccicola* (E. and E.).

PODONECTRIA GEN. NOV.

Perithecia seated on a byssoid stroma, nectriaceous; asci thick-walled, spores biseriate; ascospores elongated fusiform, multiseptate, hyaline; conidial stage, *Tetracrium*.

Three species of this genus are known, viz., *Podonectria coccophila* (E. and E.), *Podonectria Aurantii* (von Höhnel), and *Podonectria echinata* n.sp.

Podonectria coccicola (E. and E.) Petch.

I have examined the following collections of this species:—Florida (on citrus, H. S. Fawcett, in Herb. Peradeniya; on orange, Miss Southworth, January, 1910, in Herb. Kew; on purple scale of citrus, E. W. Berger, in Herb. B.M.), Dominica (F. W. South, in Herb. Peradeniya; on *Lepidosaphes beckii* on lime, F. W. South in Herb. Kew), Zululand (J. Parkin in Herb. Peradeniya), Formosa (on *Parlatoria zizyphi* Lucas and *Lepidosaphes gloverii* Pack., on *Citrus nobilis*, Taihoku, April 25, 1911, in Herb. Sapporo), Ceylon (on *Lepidosaphes* sp., on orange, in Herb. Peradeniya).

The stroma fills, or lines, the scale, and spreads out over the host plant in a thin, brownish, byssoid patch. The hyphae are agglutinated, and the margin of the patch tends to become membranous, or scarious. The stroma can easily be detached from the host plant, and then shows a smooth, white undersurface. When the scale insects are scattered, a distinct, circular stroma surrounds, or is situated at the side of, each, but where they are crowded together, the hyphae of the fungus bind the scales together, and the byssoid margin may not be developed. In the former case, the sporodochia and perithecia are scattered over the stroma (Plate IV, fig. 9); in the latter, they are usually densely clustered at the margins of the scale insects.

The sporodochium consists of a cylindrical column, surmounted by a white, usually subconical head. The column is at

first white, but becomes reddish brown; it may be up to 0·6 mm. high, and 0·4 mm. diameter, or so short that the head appears almost sessile on the scale. In the larger examples, the column is often abruptly enlarged into a disc at the apex. The external layers of the column are parenchymatous, the inner plectenchymatous. Towards the apex, the inner hyphae are moniliform, with short, inflated segments, and the conidia are borne, on very short pedicels, on the apical segment. The number of conidia on each conidiophore varies from two to five. When mature, the apical segment, with its attached conidia, separates from the conidiophore, and thus the conidia (Plate V, figs. 1–3) are liberated in clusters of two to five, united by a small, oval, or lozenge-shaped, cell at the base. The head of conidia may be up to 0·3 mm. high.

The individual conidia are hyaline, elongated, multiseptate, cylindric, usually with a long, aseptate, acuminate tip, but sometimes obtuse and rounded at the apex.

In a specimen from Florida, the conidia are 68–180 × 7 μ, mostly 160–180 μ, usually in threes, but sometimes in pairs. Seaver gives the measurement as 100–150 × 7–7·5 μ, and the number in a cluster as three to five. They have long attenuated tips.

In a specimen from Dominica, the conidia are usually in groups of three, and measure 130–250 × 7–8 μ, but sometimes one, sometimes two, spores of the triad are only 50–60 μ long. All have long attenuated tips.

In a specimen from Zululand (on ? *Citrus*, Eshowe, Nov. 1905) the conidia are chiefly in pairs, with a few triads, but, in the latter, one conidium is usually very short. They measure, in general, 100–170 × 8–9 μ, with a few, 52–82 μ long.

In a Ceylon specimen, the conidia are usually in fours, sometimes in threes, and a few in groups of five. They vary in length from 96 to 256 μ, with a few only 50–66 μ. The tips are usually long and acuminate, but some are obtuse and rounded at the apex.

The perithecia (Plate IV, fig. 9) are ovoid, or subglobose, somewhat flattened above, up to 0·5 mm. high, and 0·4 mm. diameter. Perithecia which have developed on the stroma distant from the scale may be distinctly turbinate; this is well-marked in a specimen from Dominica. They are white, but compact, at first, becoming brown or yellowish-brown, and finally dark brown, often blackish at the apex. The wall is minutely rugose. Ellis and Everhart state that the wall bears a few, scattered, white, rudimentary hairs, and Seaver describes it as "at first clothed with a few hyaline hairs," but the only "hairs" I have been able to find are loose clusters of conidia

which have fallen on the perithecia. The wall is parenchymatous, and very thick. The ostiolum is obscure; in some cases, a minute, conical ostiolum, on a very small, flat disc can be detected, but in general this is sunken and the apex of the perithecium appears merely impressed. When mature, the apex is rather widely perforate.

The asci are clavate, tapering below into a short pedicel, with a well-defined foot. They are very thick-walled (up to 8 μ), and the lumen is continued as a short, cylindrical hollow into the thickened apex. Paraphyses are numerous, linear, branched, and slightly shorter than the asci. The asci are eight-spored, with the spores usually biseriate.

Ellis and Everhart gave the dimensions of the asci as 150–190 × 20 μ, and Seaver gives 150–200 × 20 μ. My measurements are, from Florida specimens, up to 270 × 20 μ; from Dominica, 200–240 × 20–22 μ; from Zululand, up to 275 μ; from Ceylon, 250–290 × 24–28 μ. Miyabe and Sawada note that their Formosan specimens apparently differed from North American specimens in the length of the ascus, which was 189–280 μ; but Ellis and Everhart's measurement would appear to be too small.

I have not been able to observe the dehiscence of the asci. In perithecia which contain free ascospores, the asci from which they were liberated seem to have disappeared. In some gatherings, it has been noted that when the spores are mature, the lateral walls of the ascus become thin, but the apex remains thickened. In some instances, when the preparation had been subjected to pressure in an attempt to set free the spores, one issued, for the greater part of its length, through the foot; this occurred in both Ceylon and Florida specimens.

The spores (Plate V, fig. 15) are clavate, rounded above, and tapering to an obtuse point below. The sides are often not straight, but incurved somewhat irregularly about the middle. They are hyaline, multiseptate, sometimes slightly constricted at the septa. Ellis and Everhart gave the dimensions as 110–140 × 6–7 μ; Seaver, as 100–120 × 6–7 μ. My Florida specimens show spores 106–144 × 7–9 μ: Dominica, immature, but up to 100 μ: Zululand, 80–128 × 7 μ, with one ascus, abnormally constricted, in which the longest spore measured 90 μ and the shortest 52 μ: Ceylon, 95–150 × 7 μ (in the ascus), 130–176 × 8 μ (extruded spores), with one abnormal spore, almost as long as the ascus, 225 μ. Rolfs and Fawcett do not give spore measurements, but a rough estimate from their figures would appear to make them 65–80 μ long.

All the collections enumerated appear to be the same species. One point has, however, been observed in a Ceylon gathering,

which, if constant, might have occasioned some doubt. In the Florida, Dominica, and Zululand specimens, at the time when the spores are apparently fully mature, they are clearly visible, with distinctly evident septa, embedded in a small quantity of plasma in the ascus, which is still thick-walled. The figures given by Miyabe and Sawada, of the Formosan specimens, illustrate the same condition. In the Ceylon gathering, some perithecia show asci and spores identical with the above description, but, in perithecia which contain free ascospores, the appearance is different. The asci have thin walls, but a thickened apex, and the walls and septa of the contained spores can only be detected with difficulty. The ascus, at first sight, appears to be filled with granular protoplasm, containing a large number of guttae. The extruded spores (Plate V, fig. 15) have thin walls and indistinct septa, and have granular contents with numerous large guttae. Zimmermann figures this condition of the ascospore in his specimen of *Ophionectria coccicola* from Java.

It would appear from the foregoing that the second state described is that of the mature ascospore, but there is no reference to any such condition in the North American publications which deal with this species.

It is generally agreed that *Scleroderris gigaspora* Massee, from Trinidad, is *Ophionectria coccicola*. There is no type specimen in Herb. Kew.

Podonectria Aurantii (v. Höhnel) Petch.

Von Höhnel described *Puttemansia Aurantii* as follows:

Sporodochia rounded, somewhat depressed globose, dark, white pruinose, 520 × 400 μ. Conidia in groups of 2 to 7, generally 3 to 4, on a basal cell, 8–10 × 5–6 μ. Single conidia hyaline, cylindrico-fusoid, straight, thick-walled, 130–180 × 8–9 μ, 18- to 23-septate, with an aseptate tip, 10–20 μ long.

Perithecia on a plectenchymatous stroma, which is up to 250 μ thick and gradually thins to the margin, clustered, white, woolly, globose, somewhat flattened above, 570 μ diameter including the woolly outer covering, 300–400 μ without it. Ostiolum minute on a naked disc; perithecia elsewhere densely clothed with hyaline, thick-walled, septate, flexuose, woolly hairs, up to 424 μ long and 3–4 μ diameter, which are often united into fascicles. Perithecial wall 30 μ thick. Asci cylindric, attenuated below, shortly stalked, with a foot, rounded at the apex, thick-walled (6–7 μ), 180–200 × 20 μ, eight-spored, spores biseriate. Paraphyses numerous, 1 μ diameter, longer than the asci. Spores hyaline, clavate, broadest at the upper end, lower end obtuse, thin-walled, 10- to 13-septate, not constricted, 66–80 × 8–10 μ: occasionally six-septate and 52 μ long.

On a scale insect on *Citrus Aurantium*, San Paulo, Brazil.

The following description of *Ophionectria tetraspora* was given by Miyabe and Sawada.

Sporodochia globose to obovoid, greyish white, mostly 3 to 6 on a scale, 0·3–0·8 mm. diameter. Conidiophores densely packed together, moniliform, bearing 3 to 5, mostly 4, conidia on the apical cell. Conidia become free, connected together by the apical cell. Single conidium cylindrical, slightly tapering towards the acute or obtuse tip, subclavately cylindrical when half matured, 12- to 20-septate, 105–190 × 7–9·5 μ.

Perithecia caespitose, subglobose to obovoid, darkish brown, about 0·5–0·6 mm. high, 0·5 mm. diameter. Asci fasciculate, clavate, rounded at the tip, hyaline, 150–177 × 17–20 μ, with thread-like paraphyses. Ascospores eight in an ascus, clavate, hyaline to straw-coloured, 11- to 17-septate, 50–64 × 6·5–7·5 μ.

On *Parlatoria zizyphi* (Lucas) Sign., infesting *Citrus nobilis* Lour., Formosa.

Miyabe and Sawada stated that the distinguishing character of their species is the production of four conidia on the apical cell of the conidiophore, although cases of three or five occasionally occur. It was also distinguished from *Ophionectria coccicola* by the shape of the conidia, the size and shape of the asci and ascospores, and the shape of the perithecia.

From the figures and description, the chief differences would appear to be the number and shape of the conidia, and the size of the ascospores. With regard to the former, Ceylon specimens of *Ophionectria coccicola* show conidia chiefly in fours, with acute or rounded tips, associated with perithecia, which contain long ascospores. It does not appear possible, therefore, to separate *Ophionectria tetraspora* on conidial characters.

A specimen of *Ophionectria tetraspora*, on *Parlatoria zizyphi* on *Citrus nobilis*, Taihoku, Formosa, *ex* Herb. Sapporo, has been kindly submitted to me by Prof. Ito. The sporodochium is subglobose, about 0·5 mm. high, flattened above, with a base about 0·4 mm. diameter, contracted just below the head of conidia. The base is brown, and the conidia form a white flattened disc-like head. The number of spores in a cluster varies from two to five, with a predominance of fours and threes. Individual spores vary from 60 to 160 μ in length, and their tips may be either long and acute, or rounded. Some have abnormally inflated globose tips. If the shape of the sporodochium is constant, it differs from that of *Ophionectria coccicola* in being globose, not columnar, and in having the head flattened instead of conoid.

The perithecia of *Ophionectria tetraspora* (Plate IV, fig. 10) are

globose, 0·5 mm. diameter, white, or brownish white, floccose, with an outer coat of interwoven hyphae and numerous free spreading hyphae. The latter are 3–4 μ diameter, thick-walled, somewhat irregular, up to 150 μ long, and sometimes united into fascicles. The asci measure up to 230 × 20 μ. The paraphyses exhibit distinct light and dark lengths, a feature which may also be observed in *Ophionectria coccicola*, though it is not so prominent in that species. Extruded spores from one ascus measured 74–86 × 6–8 μ; in another ascus one spore was only 66 μ long. The spores are fusoid, apex subacute, base strongly attenuated, up to 14-septate.

Although I have not seen the type specimen of *Ophionectria Aurantii*, I have little hesitation in referring *Ophionectria tetraspora* to that species. In the Formosan specimens, the free hyphae appear to be less profusely developed than in the Brazilian specimens described by von Höhnel.

Parkin recorded, from Ceylon, a *Calonectria* on *Mytilaspis citricola* on orange, and another on *Chionaspis vitis* on *Loranthus*. Of the former, he stated that the perithecia were pale brown, on a small mat of hyphae, with asci 70–84 × 6–8 μ, and spindle-shaped ascospores, with two conspicuous and two inconspicuous septa, 30–46 × 6·5–7 μ. The perithecia of the latter were dark brown, 320 μ diameter, with asci 85 × 16 μ, and five-septate spores, 55 × 7·5 μ. These specimens are not now available, but it would appear probable that they were immature *Podonectria*, and from the dimensions of the spores, *Podonectria Aurantii*.

Podonectria echinata n.sp.

This species was collected on *Lepidosaphes* on Pumelo (*Citrus nobilis*) at Peradeniya, October 1919. Its conidial stage resembles that of *Podonectria Aurantii*, but the perithecia appear sufficiently distinct to constitute a new species.

The stroma is purple-brown, of matted hyphae, not extending far beyond the scale in the specimens available. The majority of the stromata bear perithecia only. The perithecia (Plate IV, fig. 7) are scattered or clustered, globose, about 0·15 mm. diameter, ostiolum not evident, pale yellow, covered with projecting, white, triangular, or conical fascicles of hyphae up to 200 μ long, and 20 μ diameter. The hyphae of the stroma are hyaline, about 4 μ diameter and thick-walled: those of the projecting fascicles are about 3 μ diameter, and are united into a parallel bundle. These bundles arise as isolated tufts from the perithecial wall. The wall of the perithecium is hyaline, rather thin, and composed of somewhat small cells. The asci vary in the same way as those of *Podonectria coccicola*. They are clavate,

with a short, thick pedicel, eight-spored, with biseriate spores; but while some are thick-walled, 116–134 × 20–24 μ, and show clearly the septate ascospores, others are thin-walled, slightly thicker at the apex, 170–190 × 24 μ, and appear at first sight to be filled with a plasma which contains innumerable large guttae, the walls and septa of the ascospores being obscure. The paraphyses are filiform, branched and irregularly flexuose at the tips, rather scanty, and, as a rule, shorter than the asci. The ascospores are clavate, sometimes acute at the apex, usually strongly attenuated below, 8- to 14-septate, not constricted at the septa, hyaline, 64–82 × 7–9 μ.

The sporodochia have a shortly columnar base, up to 0·3 mm. diameter and 0·2 mm. high, brownish yellow, becoming brown, constricted above, with generally a flat white head, up to 0·4 mm. diameter. Sometimes the head is conical. They are sometimes arranged close together at the margin of the scale, and form a continuous border on one side. The conidia are borne in clusters of 2 to 4, and are narrow-cylindric, usually with long acuminate tips, multiseptate, 60–190 × 7–8 μ.

This species differs from *Podonectria Aurantii* (*O. tetraspora*) in the colour of the perithecia, the thin perithecial wall, and the spreading teeth. An examination of Broome's specimen of *Nectria aurantiicola* B. and Br., now in Herb. British Museum, showed that it contained this species in addition, but it is not included in the description of the former.

Tetracrium rectisporum (Cooke and Massee) Petch.

In Grevillea, XVI, p. 4 (1888), Cooke and Massee described *Microcera rectispora*, on a coccus on Citrus from Australia. It had straight, multiseptate spores, up to 200 μ long. Subsequently, Cooke, in Vegetable Wasps and Plant Worms, stated that this species did not differ much from *Microcera coccophila*, but he had described it as a new species in deference to the view that minute differences in the spores were of specific value. Cooke and Massee's description of the spore suggests *Tetracrium*, and that is confirmed by an examination of the type specimen. The type in Herb. Kew consists of three small pieces of bark; there are no sporodochia present, but examination under a low power shows that the bark is covered with scattered, detached, triad spores of *Tetracrium*. Curiously enough, this is the only gathering of *Tetracrium* or *Podonectria* known from Australia. Consequently it is uncertain to which species of *Podonectria Tetracrium rectisporum* should be assigned.

BROOMELLA.

Broomella Ichnaspidis Zimm.

This species was described from specimens on *Ichnaspis filiformis* on leaves of *Elaeis* and *Coffea liberica*, collected at Buitenzorg, Java. The following details are taken from Zimmermann's description and figure.

The fungus forms a stroma, about 0·8 mm. diameter, which partly envelopes the scale insect and extends slightly beyond it. The stroma is fleshy and bears protuberances, more or less cylindric and curved, up to 0·5 mm. high. Numerous globose perithecia occur in each stroma; they are at first embedded in the protuberances, but when mature become free for about half their height. The outer layers of the stroma are colourless and translucent, the inner layers blood red, the colouring matter being held by a finely granular substance and fading on heating with chloral hydrate.

The perithecia are sharply defined from the stromatic tissue; on heating with chloral hydrate the external part of the perithecial wall, and especially the ostiolum, remains dark brown. The asci are somewhat curved, eight-spored, 95–120 μ long. The ascospores are hyaline, appearing faintly brownish in the ascus, multiseptate (up to 15), linear, generally somewhat curved, almost as long as the ascus, 4–5 μ in diameter, tapering towards the base.

Zimmermann also described a variety *major*, which occurred on a Diaspid on leaves of *Pierardia* at Buitenzorg. It differed in having asci up to 170 μ long, and ascospores up to 155 μ long, approximately of equal thickness at either end.

I have not met with any specimens of this species. It is clear that the fungus is not a *Broomella*, but nearer a *Podonectria* with a well-developed stroma. It differs from *Podonectria* in having the perithecia partly embedded in the stroma. The spore figured by Zimmermann resembles that of *Podonectria coccicola*. The description of the colour of the perithecium recalls that of *Calonectria coccidophaga*, but that of the spores is quite different.

FUSARIUM.

Fusarium epicoccum was described by McAlpine in Fungus Diseases of Citrus Fruits in Australia (1899). It was found on Red Scale, *Aspidiotus aurantii*, on branches of Mandarin orange at Burnley, near Melbourne.

McAlpine stated that it grew round the margin and on the top of the scale, usually forming crescent-shaped, effused, pale brick-red masses. The hyphae (? conidiophores) were hyaline, septate, branched, slender, 2·5–3·5 μ diameter. The conidia

were hyaline, sickle-shaped, sometimes straight, acute at both ends, one- to three-septate, 17–19 × 2·5 μ, borne terminally and laterally on the conidiophores.

The type specimen was scanty, and it is now represented by two slides in Herb. Victoria. From these slides and McAlpine's figures, it would appear that the fungus formed a thin byssoid stroma which spread over the scale and from the scale over the host plant. The margin of the stroma shows a fringe of conidiophores, but the main mass of the conidiophores appears to have been compact, and to have formed a sporodochium, parenchymatous at the base, bearing close-packed conidiophores, either simple, or branched at the base, or repeatedly branched. The latter resemble the conidiophore figured by Sawada for *Fusarium Aspidioti*. The conidia (Plate V, fig. 19) are usually terminal on the branches, but a few arise laterally below the septa, the branch apparently being suppressed. The conidiophores are up to 50 μ high. The conidia vary from almost straight with falcate tips to uniformly and strongly curved; they are three-septate, with obtuse tips. The curved conidium resembles that found in *Sphaerostilbe aurantiicola*.

PATOUILLARDIELLA.

A fungus referable to this genus has been found on an Aleyrodid in Ceylon on one occasion. Its description is as follows:

Patouillardiella Aleyrodis n.sp.

Sporodochia superficial, oval in plan, flattened pulvinate, up to 0·7 mm. long, 0·5 mm. broad, and 0·3 mm. high, orange, central mass of spores slightly darker, waxy, towards the edge radiately floccose, with a fimbriate margin. Base of sporodochium parenchymatous. Conidiophores short, stout, once or twice branched, segments slightly inflated. Conidia hyaline, cylindric, ends rounded, one-septate, not constricted, 12–18 × 1·5–2·5 μ.

On an Aleyrodid on *Ochlandra*, Gikiyanakande, Ceylon, June 1916.

Trabut, in Bull. Agric. Alger et Tunisie, 1907, p. 32, described *Microcera Parlatoriae* which occurred on *Parlatoria zizyphi* on orange, Algiers, Oct. 1907. I am indebted to Prof. Patouillard for the record of this species and an authentic specimen from Trabut. The sporodochia are discoid, flat, circular, or pulvinate, 100–200 μ diameter, compact, now orange yellow, with a slight byssoid basal weft of hyphae, situated on or at the side of the scale. The conidiophores are of the same type as in *Fusarium epicoccum*, but the branches are slightly thinner. The conidia are stout, one- to three-septate, slightly curved, or strongly curved, or hooked, 16–21 × 3·5–4 μ, and are identical with

those of *Fusarium epicoccum*. This species is *Fusarium*, not *Microcera*, and it must be referred to *Fusarium epicoccum*.

In 1909, Saccardo (Ann. Myc. VII, p. 437) described *Microcera curta* on scale insects on *Tilia platyphylla*, collected at Tamsel, Germany. The sporodochia were described as gregarious, depressed-globose, 0·5–0·75 mm. broad, reddish, rather compact, shining; and the conidia as cylindric, curved at either extremity but principally at the apex, obtuse, three-septate, not constricted, 20–25 × 4–5 μ. I have examined the specimen, Sydow, Mycotheca Germanica, No. 849, in Herb. British Museum. The sporodochia are flattened-pulvinate, compact, and somewhat waxy-looking. The conidia are chiefly strongly and uniformly curved, a few being somewhat hookshaped. This species is indistinguishable from *Fusarium epicoccum*.

Patouillard, in Bull. Soc. Myc. France, XXVIII (1912), p. 142, described *Microcera Tonduzii* on an undetermined coccid on *Ficus*, San José, Costa Rica. The sporodochia were said to be fleshy, red, conical, about 200 μ high, 120 μ diameter, composed of close-packed, fuscous or rosy-red hyphae, 4–6 μ diameter. The conidia were curved, like a horse-shoe, with acute tips, hyaline, three-septate, scarcely or not constricted, 15–21 × 4 μ. On part of the type specimen kindly submitted to me by Prof. Patouillard, I was unable to distinguish sporodochia, but conidia were present. These conidia were falcate, or unequally, curved (hooked), or strongly and equally curved, the latter being the horse-shoe conidia of the original description; they were stout, three-septate, with obtuse tips, 15–17 × 4 μ. These conidia are those of *Fusarium epicoccum* and I have little doubt that *Microcera Tonduzii* must be referred to that species.

Sawada, in 1914, described *Fusarium Aspidioti* in a paper (in Japanese) on Some Remarkable Parasitic Fungi on Insects found in Japan. The sporodochia were situated at the margin of the scale, and were circular, or long-elliptic, pulvinate, reddish, 0·2–0·8 mm. long, 0·2–0·3 mm. broad. The conidiophores (Plate V, fig. 23) were much branched, the terminal branches being 21–28 × 2·5–3 μ. The conidia were acrogenous, cylindric, strongly curved, rounded or obtusely pointed at the ends, hyaline, three-septate, 24–29 × 3·5–4·5 μ. It occurred on *Aspidiotus perniciosus* on *Pyrus communis*, Shizuoka, Honshu.

I have not seen the type of *Fusarium Aspidioti*. On a leaf of *Citrus nobilis* from Taihoku, Formosa, April 25, 1911 (*ex* Herb. Sapporo) there occurred a *Fusarium* in company with *Podonectria coccicola*, *Pseudomicrocera Henningsii*, and *Microcera aurantiicola*, on the insects *Parlatoria zizyphi* Lucas and *Lepidosaphes Gloverii* Pack. It formed an effused, white, byssoid patch overrunning the scales. There was no pulvinate sporo-

dochium, the conidiophores occurring in small clusters here and there on the byssoid stroma. The conidiophores resembled those figured by Sawada, and the conidia were either slightly curved, or strongly and equally curved, or unequally curved and somewhat hook-shaped, stout, three-septate, with obtuse tips, 14–21 × 3·5–4 μ. This specimen was undoubtedly *Fusarium epicoccum*. Sawada's species has the same conidiophores and conidia, but his measurements of the length of the conidia are greater. The latter difference might be accounted for, if the measurements were taken along the curve. On the available evidence, it would seem that *Fusarium Aspidioti* is identical with *Fusarium epicoccum*.

The equally-curved, or horse-shoe-shaped conidium exactly resembles the small curved conidium which often occurs with the perithecia or synnemata of *Sphaerostilbe aurantiicola*, and has been found in one gathering of *Sphaerostilbe flammea*. This suggests that either *Fusarium epicoccum* is a stage of *Sphaerostilbe*, or that the small *Fusarium* conidium found with the *Sphaerostilbe* is intrusive. Against the latter supposition, there is the fact that these conidia are not found in association with other species of scale insect fungi, as might be expected if their occurrence were accidental. And against the former, no sporodochia of *Fusarium epicoccum* have been found in company with *Sphaerostilbe aurantiicola*, and, with one exception, all the gatherings of *Fusarium epicoccum* do not bear any other fungus. The exception is the specimens from Formosa referred to above, and in that instance the mixture of fungi on the leaf prevents any deduction.

Fawcett described what he considered to be a new species of *Microcera* in his paper on the Fungi parasitic on *Aleyrodes citri* (1908). He stated that the fungus formed a fringe of delicate, white hyphae growing outward from the edge of the scale, and producing one-, two-, or three-celled conidia, oval to fusiform in shape. Afterwards pinkish spore masses, made up of a compact mass of lunate conidia were formed on the edge of the scale. The first conidia measure 7–12 × 3 μ; the lunate conidia are acute at both ends, three- to five-septate, and measure 28–40 × 3·5–5 μ, with a few, 52 μ.

In a specimen from Fawcett, the conidiophores form a fringe round the scale: they are up to 100 μ long, with distant, solitary, lateral branches and terminal conidia. The conidia (Plate V, fig. 12) are straight, or slightly curved, subcymbiform, ends acute, three- to four-septate, 16–50 × 4–6 μ.

This species is a *Fusarium*, but distinct from the foregoing. It may be known as *Fusarium Aleyrodis*.

SYSTEMATIC LIST

HYPOCREACEAE.

NECTRIA.

Nectria diploa B. and C., Jour. Linn. Soc. x (1868), p. 378; *Nectria coccorum* Speg., Fungi Guaranitici, Pug. 1, No. 234 (? 1886); *Nectria coccogena* Speg., Fungi Puigg., No. 289 (1889); *Nectria oidioides* Speg., *myrticola* Rehm, Ule, Herb. Brasiliense, No. 1288; ? *Nectria coccophila* Nomura, Imp. Agric. Expt. Sta., Rep. 18, p. 105 (1901); ? *Nectria variabilis* Hara, Bot. Mag. XXVIII, p. 339 (1914).

Conidial stage—*Pseudomicrocera Henningsii* (Koorders) Petch; *Aschersonia Henningsii* Koord., Bot. Untersuch. (1907), p. 213; *Microcera Fujikuroi* Miyabe and Sawada, Jour. Coll. Agric., Tohoku Imp. Univ., Sapporo, v, pt. 3 (March 1913), pp. 73–90; *Microcera Merrillii* Syd., Ann. Myc., XII, p. 576 (1914); *Microcera Henningsii* (Koord.) Petch, Ann. Perad., v, p. 533 (1914).

Exsiccati. Balansa, Pl. de Paraguay, 4046; Roumeguère, Fungi Selecti Exsicc., 5229; Roumeguère, Fungi Gallici Exsicc., 3547; Ule, Herb. Brasiliense, 1288.

Perithecia clustered on the old conidial stroma, globose, up to 0·4 mm. diameter, bright red, darker round the ostiolum, covered with large warts up to 0·1 mm. high which are sometimes confluent and form a continuous crust; old herbarium specimens orange red or orange yellow; ostiolum minute, conical; asci clavate, sessile, 4-spored, 64–68 × 12 μ or eight-spored, 96–116 × 10–14 μ; ascospores pale yellow, elliptical, narrow-oval, or subcymbiform, ends obtuse, one-septate, not constricted at the septum, 16–32 × 6–9 μ.

Stroma compact yellowish white, or pinkish red, surrounding the scale; sporodochia horizontal or oblique consisting of a red, pulvinate, or subglobose base, up to 0·6 mm. broad and 0·5 mm. high, surmounted by a white conical tip, up to 0·6 mm. high: conidiophores branched, up to 60 μ long; conidia hyaline, arcuate, regularly curved, acute, three- to five-septate, 40–100 × 3–5 μ: in var. *longispora*, 92–134 × 3 μ.

Distribution. Perithecial stage—Cuba-Brazil; Paraguay; Ceylon; Mauritius. Conidial stage—Brazil, Paraguay; Florida; Cuba; Grenada (W.I.); Ceylon; India; Java; Mauritius; Burma; Australia; Philippines; Formosa; West Africa (var. *longispora*).

Nectria Tuberculariae Petch n.sp.

Perithecia scattered or clustered, on the scale, or on a white byssoid stroma, or in the sporodochia, globose, pale flesh coloured, white pruinose, 0·2 mm. diameter; ostiolum minute, conical; asci cylindric, eight-spored, spores obliquely uniseriate,

50–62 × 4 μ; ascospores oval or oblong-oval, one-septate, not constricted, hyaline, minutely warted, 6–9 × 2·5–5 μ.

Conidial stage—*Tuberculariа coccicola* Stev., Ann. Rep. Ins. Expt. Sta. Porto Rico, 1917.

Sporodochia scattered or clustered, flattened pulvinate, compact, 0·5–4 mm., sometimes confluent, with or without a white byssoid stroma, pink, becoming white when old; conidiophores branched, up to 36 μ long; conidia cylindric with rounded ends, up to 6 × 2·5 μ, or oval, 3–5 × 2–3 μ, or globose, 2·5 μ diameter, hyaline, continuous.

Distribution. Perithecial stage—Ceylon; India. Conidial stage—Ceylon; India; Porto Rico.

Nectria barbata Petch, n.sp.

Perithecia scattered, conoid or subglobose, 0·2 mm. diameter, 0·3 mm. high, yellow brown or dark amber, subtranslucent, minutely rugose, collapsing, with a ring of erect, white, rigid hairs below the ostiolum; ostiolum broadly papillate or obtusely conical; hairs up to 50 μ high, 4 μ diameter, equal, or slightly inflated at the tip; asci cylindrico-clavate, eight-spored, spores uniseriate, obliquely uniseriate, or transverse, 66 × 6–8 μ; ascospores hyaline, oblong-oval, ends broadly rounded, one-septate, strongly constricted, 6–8 × 3–5 μ.

Distribution. Ceylon.

LISEA.

Lisea Parlatoriae Zimm., Centralb. f. Bakt., Abt. 2, VII (1901), p. 873.

Perithecia crowded, superficial, globose, 0·2–0·25 mm. high, and 0·15–0·18 mm. diameter, black; ostiolum papillate; wall dark violet to black by transmitted light; asci cylindric, eight-spored; ascospores elliptic, obtuse, one-septate, not constricted, hyaline or slightly brownish, 9–12 × 4·5 μ.

Distribution. Java.

SPHAEROSTILBE.

Sphaerostilbe aurantiicola (B. and Br.) Petch, Ann. Perad., VII, p. 119 (1920); *Nectria aurantiicola* B. and Br., Jour. Linn. Soc., XIV, p. 117 (1873); *Sphaerostilbe coccophila* Tul. (1865), quoad Rabenhorst, Fungi Europaei Exsicc., Ed. nov., Ser. secunda, Nos. 262, 269; *Corallomyces aurantiicola* (B. and Br.) v. H., Frag. zur Myk., XIV, No. 729.

Conidial stage—*Microcera aurantiicola* Petch.

Exsiccati. Rabenhorst, Fungi Europaei Exsicc., Ed. nov., Ser. secunda, Nos. 262, 269; Erbar. Crittogam. Ital., Nos. 539, 543, Ser. II, 542; Ravenel, Fungi Amer. Exsicc., No. 286.

Perithecia usually scattered, without evident stroma, at first orange red, becoming blood red, darker round the ostiolum,

subtranslucent, sometimes with a few yellow granules, usually smooth, subglobose or subconoid, 0·2–0·25 mm. diameter, collapsing laterally; ostiolum papillate or not elevated; asci cylindro-clavate, scarcely pedicellate, eight-spored, spores uniseriate or obliquely uniseriate, 66–90 × 6–8 μ; paraphyses diffluent; ascospores oval, obtuse, hyaline to yellowish, one-septate, not constricted, wall rather thick and minutely warted, 9–14 × 4–6 μ.

Synnemata stilboid or clavate, up to 2 mm. high, 0·4 mm. diameter below, 0·6 mm. diameter above, or flattened pulvinate, sessile, up to 0·6 mm. long, 0·4 mm. broad, orange red to blood red, subtranslucent, becoming hard and horny when dry, arising from a narrow yellowish white loose stroma; conidia narrow cylindric, tapering at the ends, straight or slightly curved, ends falcate, hyaline or yellowish, up to eleven-septate, septa usually distinct, 70–120 × 5–7 μ. A small strongly curved *Fusarium* conidium, three-septate, obtuse, hyaline, 12–18 × 3–4 μ is often present.

Distribution. Ceylon; India; Madagascar; Japan; Formosa; Dominica (W.I.); Georgia (U.S.A.); Florida (U.S.A.); Italy.

Sphaerostilbe flammea Tul., Selecta Carp. Fung. I, p. 130 (1861); *Stilbum flammeum* Tul., Acta hebdom. Acad. Sci. par., XLII, p. 704, et Ann. Sci. Nat., Ser. 4, vol. V (1856), p. 114; *Nectria muscivora* Berk., Ravenel, Fungi Car. Exsicc., No. 57, non *Nectria muscivora* B. and Br., Ann. Mag. Nat. Hist., Ser. 2, vol. VII, p. 188 (1851); *Nectria laeticolor* B. and C., Jour. Linn. Soc. X (1868), p. 377; *Nectria aglaothele* B. and C., Grevillea IV, p. 45 (1875); *Nectria subcoccinea* Sacc. and Ellis, Michelia, II, p. 570 (1882); *Nectria Passeriniana* Cooke, Grevillea, XII, p. 81 (1884); *Sphaerostilbe coccophila* Tul. (1865), quoad Desmazières, Plantes Crypt. de France, Ed. II, Ser. I, No. 1350 and Ed. I, Ser. I, No. 1750.

Conidial stage—*Microcera coccophila* Desm., Ann. Sci. Nat., Ser. 3, vol. X (1848), p. 539; *Atractium flammeum* Berk. and Rav. Ann. Mag. Nat. Hist., Ser. 2, vol. XIII (1854), p. 461; *Microcera pluriseptata* Cke. and Massee, Grevillea, XVII, p. 43; ? *Fusarium coccinellum* (Kalch.) Thuem., Mycotheca Univ., No. 782, *Fusisporium coccinellum* Kalch., Flora, LIX (1876), p. 426.

Exsiccati. Desmazières, Plantes Cryptogames de France, Ed. I, Ser. I, No. 1750, and Ed. II, Ser. I, No. 1350; Ravenel, Fungi Car. Exsicc., No. 57 and V. No. 86; Fungi Cubenses Wrightiani, No. 765; Ellis, North American Fungi, Nos. 1229 and 1333; Cooke, Fungi Brit. Exsicc., No. 350, and Ed. II, No. 534; ? Thuemen, Mycotheca Univ., No. 782.

Perithecia usually clustered on a well-developed plectenchymatous stroma, bright orange red, darker round the ostiolum,

glabrous, slightly rugose, opaque, globose, 0·3 mm. diameter, usually collapsing centrally; ostiolum minute, conical, or scarcely evident; asci cylindric, scarcely pedicellate, eight-spored, spores obliquely uniseriate, 90–116 × 8–10 μ; paraphyses diffluent; ascospores elliptic, obtuse, one-septate, not constricted, hyaline, or yellowish, minutely warted, 12–19 × 5–8 μ.

Synnemata arising from a white or pinkish stroma round the scale, stilboid up to 2·5 mm. high, more usually clavate or conical, up to 0·6 mm. high, 0·25 mm. diameter, or flattened pulvinate, up to 0·75 mm. long, 0·5 mm. broad, orange red to blood red, usually clothed with erect fascicles of hyphae at the base; conidia fusiform, straight, or straight with falcate tips, or slightly curved, up to eleven-septate, but usually with few, irregularly spaced, and obscure septa, hyaline, 50–105 × 5–7 μ, sometimes only 35 μ long. A small strongly curved *Fusarium* conidium, three-septate, obtuse, hyaline, 18 × 4 μ, is sometimes present.

Distribution. United States (Pennsylvania; Massachusetts; South Carolina; Georgia; Louisiana; Texas; Florida); Cuba; Brazil; Argentina; France; England; Italy; ? South Africa; ? New Zealand; ? Australia.

Sphaerostilbe coccidophthora (Zimm.) Petch, Ann. Perad., VII, p. 131 (1920); *Nectria coccidophthora* Zimm., Centralb. f. Bakt., Abt. II, VII, p. 873 (1901).

Conidial stage—*Microcera coccidophthora* Petch.

Perithecia scattered or clustered, sometimes on a narrow floccose stroma, orange red becoming blood red, darker round the ostiolum, subtranslucent, covered with yellow or yellowish red granules, subglobose or subconoid, collapsing laterally; ostiolum usually papillate; asci cylindrico-clavate, shortly pedicellate, eight-spored, spores obliquely uniseriate, 84–136 × 8–10 μ; paraphyses linear, diffluent; ascospores oval or broadly oval, obtuse, hyaline to yellowish, one-septate, not constricted, wall thick and minutely warted, 13–22 × 7–9 μ.

Synnemata arising from a narrow yellowish white, loose, floccose stroma round the scale, clavate, up to 1·4 mm. high, 0·25 mm. diameter below, 0·3 mm. diameter above, or subsessile, ovoid or conical, up to 0·4 mm. high, 0·25 mm. diameter, orange red to blood red, pale towards the base, subtranslucent when fresh, becoming hard and horny when dry; conidia cylindric, tapering at the ends, almost straight, tips falcate, hyaline, up to eleven-septate, usually with large numbers of aseptate conidia, 62–106 × 6–7 μ.

Distribution. Ceylon; India; Java; Seychelles.

CALONECTRIA.

Calonectria coccidophaga Petch n.sp.

Conidial stage– *Discofusarium tasmaniense* (McAlp.) Petch; *Microcera tasmaniensis* McAlp., Agric. Jour. Victoria, II (1904), pp. 646–648; *Microcera Mytilaspis* McAlp., *loc. cit.*

Perithecia clustered, on a parenchymatous, yellowish stroma, globose, 0·4 mm. diameter, horny-looking, black above, pinkish-yellow below, pruinose except at the apex; apex papillate or flat and discoid with a punctiform ostiolum; wall thick, rose red in section; asci clavate, eight-spored, spores biseriate above, uniseriate below, 120–140 × 14–16 μ; paraphyses stout, branched; ascospores oblong-oval or subcymbiform, straight or curved, obtuse, three-septate, constricted at the septa, 22–34 × 8–9 μ.

Sporodochia clustered, sessile, pulvinate or subglobose, up to 0·3 mm. diameter, or discoid, up to 0·8 mm. long, 0·6 mm. broad, sessile or shortly stalked, salmon pink when fresh, becoming yellow with a white margin in herbarium specimens; conidiophores short, repeatedly branched, with short, slightly inflated segments; conidia fusiform, slightly falcate or almost straight, obtuse, up to five-septate, hyaline, 30–58 × 4–6 μ.

Distribution. Victoria; Tasmania.

PODONECTRIA GEN. NOV.

Perithecia on a byssoid stroma, nectriaceous; asci thick-walled, spores biseriate; ascospores elongated fusiform, multi-septate, hyaline; conidial stage, *Tetracrium.*

Podonectria coccicola (E. and E.) Petch; *Nectria* (*Ophionectria*) *coccicola* E. and E., Jour. of Myc. II, p. 39 (1886); *Dialonectria coccicola* E. and E., Jour. of Myc., II, p. 137 (1886); *Ophionectria coccicola* (E. and E.) Berl. and Vogl., Saccardo, Syll., Add. IV, p. 218 (1886); *Scoleconectria coccicola* (E. and E.) Seaver, Mycologia, I, p. 198 (1909); *Puttemansia coccicola* (E. and E.) v. Höhnel, Fragm. zur Myk., XIII, p. 30 (1911); *Scleroderris gigaspora* Massee, Kew Bulletin (1910), p. 3.

Conidial stage—*Tetracrium coccicolum* v. Höhnel, *loc. cit.*

Perithecia on a byssoid stroma, ovoid or subglobose, sometimes turbinate, up to 0·5 mm. high, 0·4 mm. diameter, brown or blackish brown, minutely rugose, glabrous, ostiolum obscure; wall parenchymatous very thick; asci clavate, shortly pedicellate, pedate, thick walled, eight-spored, spores biseriate, 200–290 × 20–28 μ; paraphyses numerous, filiform, branched; ascospores fusoid or clavate, obtuse, hyaline, multiseptate, 80–176 × 7–8 μ.

Sporodochia consisting of a brown, cylindric or ovoid, parenchymatous base, up to 0·6 mm. high, 0·4 mm. diameter, sur-

mounted by a white subconical head of conidia; conidiophores short, moniliform; conidia detached in clusters of two to five, united at the base by a small lozenge-shaped cell; individual conidia hyaline, cylindric, multiseptate, usually with a long aseptate acuminate tip, sometimes equal, obtuse and rounded at the apex, 50–256 × 7–9 μ.

Distribution. Ceylon; Java; Formosa; Zululand; Florida; Dominica (W.I.).

Podonectria Aurantii (v. Höhnel) Petch; *Puttemansia Aurantii* v. Höhnel, Fragmente zur Mykologie, XIII (1911), p. 28; *Ophionectria tetraspora* Miyabe and Sawada, Jour. Coll. Agric., Tohuku Imp. Univ., Sapporo, v, pt. 3 (March 1913), p. 85.

Conidial stage—*Tetracrium Aurantii* P. Henn., Hedwigia, XLI (1902), p. 116.

Perithecia on a byssoid stroma, globose, 0·5 mm. diameter, white or brownish white, floccose, densely clothed with thick-walled, irregular, septate, hyaline hyphae which are sometimes united into fascicles; ostiolum minute on a naked disc; wall thick, parenchymatous; asci clavate, thick-walled, shortly pedicellate, pedate, eight-spored, spores biseriate, 150–230 × 20 μ; paraphyses numerous, filiform, branched; ascospores fusoid or clavate, obtuse, hyaline to yellowish, multiseptate, 66–86 × 7–10 μ.

Sporodochia with a globose or obovoid brown base, about 0·5 mm. high, 0·4 mm. diameter, with a flattened disc-like white head of conidia (in the specimens examined); conidiophores short moniliform; conidia detached in clusters of two to five, united at the base by a small lozenge-shaped cell; individual conidia cylindric, hyaline, multiseptate, with long, acute, aseptate tips, or equal and rounded at the apex, 60–190 × 7–9 μ.

Distribution. Brazil; Formosa.

Podonectria echinata Petch n.sp.

Conidial stage—*Tetracrium echinatum* Petch n.sp.

Perithecia on a byssoid stroma, globose, about 0·15 mm. diameter, pale yellow, clothed with white, triangular or conical, projecting fascicles of hyphae up to 200 μ long and 20 μ diameter; ostiolum not evident; wall rather thin, hyaline by transmitted light; asci clavate, thick-walled, shortly pedicellate, pedate, eight-spored, spores biseriate, 116–190 × 20–24 μ; paraphyses numerous, filiform, branched; ascospores clavate, sometimes acute at the apex, usually strongly attenuated below, multiseptate, hyaline, 64–82 × 7–9 μ.

Sporodochia with a short columnar base, up to 0·3 mm. diameter, 0·2 mm. high, constricted above, brownish yellow, becoming brown, generally with a flat discoid head of conidia, up to 0·4 mm. diameter; conidiophores short moniliform; conidia

detached in clusters of two to four, united at the base by a small lozenge-shaped cell; individual conidia cylindric, hyaline, multiseptate, usually with long, acuminate, aseptate tips, 60–190 × 7–8 μ.

Distribution. Ceylon.

BROOMELLA.

Broomella Ichnaspidis Zimm., Centralb. f. Bakt., Abt. 2, VII (1901), p. 874.

Stroma about 0·8 mm. diameter, fleshy, outer layers colourless, inner layers blood red, tuberculate, tubercles more or less cylindric and curved and up to 0·5 mm. high; perithecia at first embedded in the tubercles, becoming free for half their height; asci somewhat curved, eight-spored, 95–120 μ long; ascospores hyaline or with a brown tinge, multiseptate, linear, generally somewhat curved, tapering towards the base, almost as long as the ascus, 4–5 μ diameter.

var. *major*. Asci up to 170 μ long; ascospores up to 155 μ long, of equal thickness at either end.

Distribution. Java.

STILBACEAE.

MICROCERA.

Microcera aurantiicola Petch.

Conidial stage of *Sphaerostilbe aurantiicola* (B. and Br.) Petch, see p. 124.

Microcera coccophila Desm., Ann. Sci. Nat., Ser. 3, vol. X (1848), p. 359; *Atractium flammeum* Berk. and Rav., Ann. Mag. Nat. Hist., Ser. 2, vol. XIII (1854), p. 461; *Microcera pluriseptata* Cke. and Massee, Grevillea, XVII, p. 43 (1888); ? *Fusarium coccinellum* (Kalch.) Thuem., Mycotheca Univ., No. 782, *Fusisporium coccinellum* Kalch, Flora, LIX (1876), p. 426.

Conidial stage of *Sphaerostilbe flammea* Tul., see p. 115.

Microcera coccidophthora Petch.

Conidial stage of *Sphaerostilbe coccidophthora* (Zimm.) Petch, see p. 129.

TUBERCULARIACEAE.

TUBERCULARIA.

Tubercularia coccicola Stevenson, Ann. Rep. Ins. Exp. Sta., Porto Rico 1917.

Conidial stage of *Nectria Tuberculariae* Petch; see p. 157.

PATOUILLARDIELLA.

Patouillardiella Aleyrodis Petch, n.sp.

Sporodochia oval, flattened pulvinate, up to 0·7 mm. long, 0·5 mm. broad, 0·3 mm. high, orange, central mass of conidia slightly darker, waxy, towards the edge radiately floccose with

a fimbriate margin; conidiophores short, stout, once or twice branched, segments slightly inflated; conidia hyaline, cylindric, ends rounded, one-septate, not constricted, 12–18 × 1·5–2·5 μ.

Distribution. Ceylon.

FUSARIUM.

Fusarium epicoccum McAlp., Fungus diseases of Citrus trees in Australia (1899); *Microcera Parlatoriae* Trabut, Bull. Agric. Alger et Tunisie, 1907, p. 32; *Microcera curta* Sacc., Ann. Myc., VII, p. 437 (1909); *Microcera Tonduzii* Pat., Bull. Soc. Myc. France, XXVIII (1912), p. 142; *Fusarium Aspidioti* Sawada, Bot. Mag., Tokyo, XXVIII, p. 312 (1914).

Sporodochium flattened pulvinate or discoid, up to 0·75 mm. diameter, pale red, sometimes seated on a white byssoid stroma, parenchymatous at the base; conidiophores simple or repeatedly branched, up to 50 μ long; conidia hyaline, stout, obtuse, up to three-septate, slightly curved, or curved at one end, or strongly curved, 16–25 × 2·5–4 μ.

Distribution. Australia; Japan; Algeria; Germany; Costa Rica.

Fusarium Aleyrodis Petch, n.sp.; *Microcera* sp., Fawcett, Fungi parasitic on Aleyrodes Citri (1908).

Stroma white, thin, byssoid; conidiophores scattered or clustered, up to 100 μ long, with distant, solitary lateral branches; conidia cylindric, straight or slightly curved, subcymbiform, acute, three- to four-septate, 16–50 × 4–6 μ.

Distribution. Florida.

PSEUDOMICROCERA GEN. NOV.

Sporodochia conical; base ovoid, cylindric, or pulvinate, parenchymatous, or composed of interwoven irregular hyphae, surmounted by a discoid layer of conidiophores with a marginal zone of long hyphae, which are united into a continuous sheet, or into fascicles of varying breadth which are connivent at the apex; conidiophores branched; conidia elongated, narrow, curved, septate, hyaline.

Pseudomicrocera Henningsii (Koord.) Petch; *Aschersonia Henningsii* Koord., Bot. Untersuch. (1907), p. 213; *Microcera Fujikuroi* Miyabe and Sawada, Jour. Coll. Agric., Tohuku Imp. Univ., Sapporo, v. pt. 3 (March 1913), pp. 73–90; *Microcera Merrillii* Syd., Ann. Myc., XII, p. 576 (1914); *Microcera Henningsii* (Koord.) Petch., Ann. Perad., v, p. 533 (1914).

The conidial stage of *Nectria diploa* B. and C.; see p. 157.

DISCOFUSARIUM GEN. NOV.

Sporodochium discoid, sessile or shortly stalked, the external layers composed of parallel hyphae continuous from the base,

extending above the disc and forming an incurved margin; disc composed of branched conidiophores; conidia hyaline, fusarioid, multiseptate.

Discofusarium tasmaniense (McAlp.) Petch; *Microcera tasmaniensis* McAlp., Agric. Jour. Victoria, II (1904), pp. 646–648; *Microcera Mytilaspis* McAlp., *loc. cit.*

The conidial stage of *Calonectria coccidophaga* Petch; see p. 161.

TETRACRIUM.

Tetracrium coccicolum v. Höhnel, Fragm. zur Myk., XIII, p. 30 (1911).

The conidial stage of *Podonectria coccicola* (E. and E.) Petch; see p. 161.

Tetracrium Aurantii P. Henn., Hedwigia, XLI (1902), p. 116.

The conidial stage of *Podonectria Aurantii* (v. H.) Petch; see p. 162.

Tetracrium echinatum Petch, n.sp.

The conidial stage of *Podonectria echinata* Petch; see p. 162.

Tetracrium rectisporum (Cke. and Massee) Petch; *Microcera rectispora* Cke. and Massee, Grevillea, XVI, p. 4 (1888).

The type specimen does not contain sporodochia or perithecia, but only scattered, detached conidial clusters of some *Tetracrium*.

EXPLANATION OF PLATES.

PLATE III.

Fig. 1. *Sphaerostilbe aurantiicola*, conidial (*Microcera*) stage, on *Aspidiotus*, Ceylon specimen. × 15.

Fig. 2. *Sphaerostilbe aurantiicola*, conidial (*Microcera*) stage, sessile form, on *Aspidiotus*, Ceylon specimen. × 10.

Fig. 3. *Sphaerostilbe aurantiicola*, perithecial stage, on *Aspidiotus*, Ceylon specimen. × 12.

Fig. 4. *Sphaerostilbe aurantiicola*, perithecium, Ceylon specimen. × 60.

Fig. 5. *Sphaerostilbe aurantiicola*, old conidial (*Microcera*) stage after most of the conidia have disappeared, showing the empty sheath at the apex, specimen from Formosa, on a scale on apple. × 12.

Fig. 6. *Sphaerostilbe coccidophthora*, perithecium, Ceylon specimen. × 60.

Fig. 7. *Sphaerostilbe flammea*, perithecial stage, *ex* herb. Spegazzini. × 15.

Fig. 8. *Sphaerostilbe flammea*, conidial (*Microcera*) stage, *ex* herb. Spegazzini. × 15.

Fig. 9. *Pseudomicrocera Henningsii*, on *Aonidia*, stroma circumferential, the central area of the scale not covered, sporodochium arising from the inner margin of the stroma, dry weather form, Ceylon. × 12.

Fig. 10. *Pseudomicrocera Henningsii*, on *Aonidia*, stroma confined to one side, dry weather form, Ceylon. × 12.

Fig. 11. *Pseudomicrocera Henningsii*, sporodochium with well-developed parenchymatous base, specimen from Florida. × 15.

Fig. 12. *Pseudomicrocera Henningsii*, on *Aspidiotus*, stroma marginal, base of sporodochium feebly developed, Ceylon. × 20.

Fig. 13. *Nectria diploa*, perithecia, with effete sporodochia, Ceylon. × 50.

Fig. 14. *Nectria barbata*, perithecium, Ceylon. × 80.

PLATE IV.

Fig. 1. *Discofusarium tasmaniense*, fully developed specimen *ex* type of *Microcera Mytilaspis*. × 12.
Fig. 2. *Discofusarium tasmaniense*, young specimens, *ex* type of *Microcera tasmaniensis*. × 12.
Fig. 3. *Calonectria coccidophaga*, group of perithecia, one cut open. × 12.
Fig. 4. *Calonectria coccidophaga*, group of old perithecia. × 12.
Fig. 5. *Tubercularia coccicola*, group of sporodochia on *Lepidosaphes*, with radiating marginal stroma, Ceylon specimen. × 12.
Fig. 6. *Tubercularia coccicola*, group of sporodochia on *Lepidosaphes*, the stroma covered by a *Septobasidium*, Ceylon specimen. × 12.
Fig. 7. *Podonectria echinata*, group of perithecia on *Lepidosaphes*. × 12.
Fig. 8. *Nectria Tuberculariae*, on *Lepidosaphes*. × 12.
Fig. 9. *Podonectria coccicola*, perithecia and sporodochium, on *Lepidosaphes*, specimen from West Indies. × 12.
Fig. 10. *Podonectria Aurantii*, perithecia and sporodochium (second from right), on *Parlatoria*, *ex* type of *Ophionectria tetraspora*, Formosa. × 10.

PLATE V.

Fig. 1. *Podonectria coccicola*, conidia, Glenugie, Ceylon. × 400.
Fig. 2. *Podonectria coccicola*, conidia, Zululand. × 400.
Fig. 3. *Podonectria coccicola*, conidia, Glenugie, Ceylon. × 400.
Fig. 4. Hairs from the perithecium of *Nectria barbata*. × 300.
Fig. 5. *Nectria barbata*, ascus. × 600.
Fig. 6. *Nectria barbata*, ascospores. × 600.
Fig. 7. *Calonectria coccidophaga*, ascospores. × 400.
Fig. 8. Sterile sheaths of *Pseudomicrocera Henningsii*. × 20; *a*, back view; *b*, lateral view; *c*, front view.
Fig. 9. *Nectria Tuberculariae*, ascospores. × 600.
Fig. 10. *Sphaerostilbe aurantiicola*, conidia. × 500.
Fig. 11. *Sphaerostilbe aurantiicola*, small curved conidium. × 500.
Fig. 12. Conidiophore and conidia of *Fusarium Aleyrodis*. × 400.
Fig. 13. Conidiophore and conidia of *Discofusarium Mytilaspidis*. × 350.
Fig. 14. *Podonectria Aurantii*, ascospore. × 400.
Fig. 15. *Podonectria coccicola*, ascospore (? mature form). × 400.
Fig. 16. Bases of the conidiophores of *Sphaerostilbe aurantiicola*, showing ladder connection. × 500.
Fig. 17. *Pseudomicrocera Henningsii*, conidia. × 600.
Fig. 18. *Nectria coccogena*, ascospore. × 500.
Fig. 19. *Fusarium epicoccum*, conidia, *ex* type. × 600.
Fig. 20. *Pseudomicrocera Henningsii*, form on *Aonidia*, Ceylon, viewed from the lower surface. × 12 (diagrammatic).
Fig. 21. *Pseudomicrocera Henningsii*, Florida, in longitudinal section. × 12 (diagrammatic).
Fig. 22. *Nectria diploa*, ascospores, Ceylon. × 500.
Fig. 23. *Fusarium Aspidioti*, conidiophores and conidia. × 400 (after Sawada).

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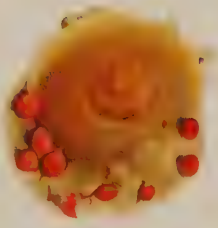

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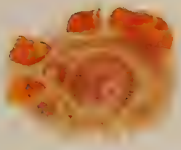

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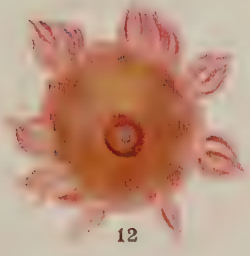

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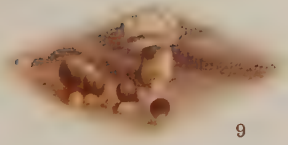

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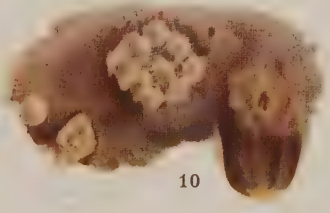

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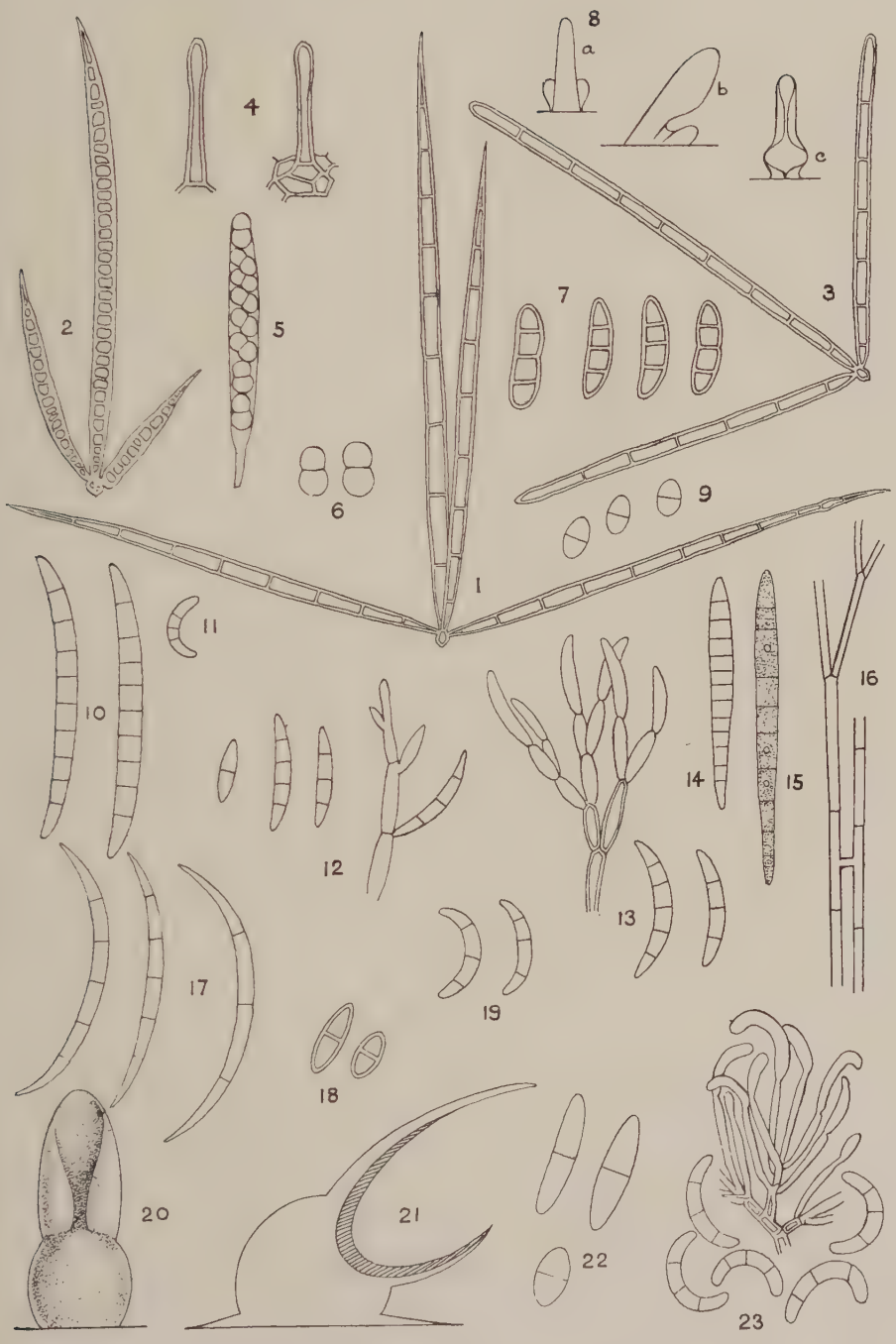
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THE IMPERIAL BUREAU OF MYCOLOGY.

By E. J. Butler, C.I.E., D.Sc., M.B., F.L.S.

The movement which led to the establishment of the Imperial Bureau of Mycology originated from several different sources.

In the first place it had long been felt by many that the remarkable success that had attended the formation of the Imperial Bureau of Entomology, in encouraging and co-ordinating entomological work in relation to agriculture throughout the Empire was justification for the establishment of a similar organization to deal with the other great class of destructive agencies in agriculture, namely the diseases of plants caused by fungi. Then the shortage of supplies during the war emphasized the importance of conserving raw products obtained from the vegetable kingdom, for the provision of which this country is so dependent on the agricultural prosperity of the Overseas Empire. The bearing of economic mycology, especially plant pathology, in this matter was brought into prominence by a discussion at the Newcastle meeting of the British Association in 1916, at which specific proposals were made for the establishment of an Imperial Bureau of Mycology as a co-ordinating and stimulating agency for helping on the study of the diseases of plants throughout the Empire. At the same time some of the mycological workers in the overseas parts of the Empire began to press for improved facilities in England to replace the help in certain directions which they had been accustomed to obtain from foreign countries, some of which became enemy countries in 1914.

Thus the movement from within met with a similar movement from outside. The proposal to establish a Bureau of Mycology in London was laid before the Imperial War Conference in 1918, and, backed by the support of that powerful body, was referred to the Overseas Governments for consideration. The latter approved, and undertook to finance the Bureau for a period of three years in the first instance. On the initiative of the Colonial Office a Managing Committee was formed, comprising a number of well-known biologists with Viscount Harcourt as their Chairman, and the Bureau commenced work towards the end of last year. Quarters have been found for it in the former laboratory of the Plant Pests Branch of the Ministry of Agriculture at 17, Kew Green, as this Branch has been transferred to Harpenden. At Kew the Bureau has the advantage of proximity to the fine library and collections of the Royal

Botanic Gardens and it will work in close co-operation with the latter institution.

The following is a brief sketch of the proposed activities of the Bureau, which have been worked out in consultation with mycologists both here and in the colonies. As its primary function is to be of use to economic mycologists in the overseas parts of the Empire, the views of the latter have naturally great weight, and it is already evident that a great deal of consideration is being given by the Colonial Departments of Agriculture to the best methods of making the Bureau of real use. After having had nearly twenty years practical experience in India of the directions in which help is needed it was not difficult for me to suggest what the broad lines of our work should be; other useful proposals have been sent in from abroad, and there is no doubt that still more will follow.

There appear to be two main directions which must be followed if the Bureau is to justify its existence; and there are many subsidiary activities which will greatly add to its utility.

The two main directions are of equal importance. They are the accumulation and distribution of information on all matters connected with the diseases of plants, and the identification of specimens of injurious fungi.

For the former the Bureau must endeavour to keep in touch with mycological and pathological work going on in all parts of the world, and must index all the useful literature so that past and current work on any particular subject can be readily traced. The oversea worker is often in too isolated a position to be able to do this for himself: his first need is to know what has been done elsewhere on the problems with which he is faced and whether there is any recent or current work on them; and for this we hope to provide the necessary organization at the Bureau. The number of journals, periodical reports and the like that will have to be examined is very large, probably approaching four figures, but many of these have only an occasional reference of value. As soon as the necessary additional funds are provided (the original proposals in 1918 were calculated on a war basis) it is proposed to start a periodical abstracting journal on the lines of *The Review of Applied Entomology*, published by the Imperial Bureau of Entomology. But it is clear that this in itself will not be enough. We must be able to issue, on demand, the complete references to past work on the problems on which individual workers overseas are engaged. It will naturally take time before we can build up complete subject catalogues to enable this to be done readily. Besides the general subject catalogue we will require to compile, as soon as possible, a host-plant index, giving the fungi recorded on economically

important plants, for which the basis already exists in Vol. XIII and the subsequent volumes of Saccardo's *Sylloge Fungorum*, but which requires to be amplified in the direction followed in Oudemans' *Enumeratio Systematica Fungorum*. The latter only deals with the European flora, includes all plants, economic or not, and is of very limited value to, say, a worker in the tropics, as will be readily realized when we find only a single entry under the family *Zingiberaceae*, which includes such important crops as ginger and turmeric, both subject to several serious diseases. In addition to supplying references we must be prepared also to furnish abstracts and, in certain cases, to lend out original papers. This will be of great value to isolated workers and I attach great importance to it.

The next main line of work is to organize a system for the prompt identification of injurious fungi. In this respect mycologists have not at present as good facilities as those possessed by entomologists. Specialists in particular groups are not as readily available to us as to them; we are fewer in number and the amateur who specializes in a particular group is greatly to seek when once we descend below the higher fungi and enter the groups to which the majority of the injurious species belong. The organization here will have to be to some extent international as it is in entomology, and we must aim at being able to refer a species in a particular family or genus to the recognized authority on that group—when there is one. If, as I hope and expect, very large collections of fungi from the tropics and elsewhere are sent in, the Bureau can provide such material as to make it very attractive to systematic mycologists to specialize in certain families.

Arising out of this branch of the work is the comparative study of pathogenic fungi. This should be an important feature of the work of the Bureau and there is urgent need for the critical examination, with culture work, of such tropical pathogens as the *Phytophthoras*, *Diplodias*, *Glomerellas*, etc. When this work is under way there is no reason why it should not be developed into a culture-supplying organization, primarily to deal with tropical and sub-tropical forms. The chief difficulty in this is the want of suitable culture rooms at the Bureau, but a recent very helpful offer from the Lister Institute has suggested a way out.

Gradually there should be at the Bureau a very good herbarium of parasitic fungi. Such a collection will be essential for our own systematic work—for when all is said and done there will be a great deal of systematic work which the Bureau will have to undertake itself—and will be invaluable for reference purposes. Duplicates will be kept in as large quantities as

possible and named collections issued to various centres, especially the laboratories overseas. Types will not be kept at the Bureau as the collections there will be essentially working collections, the types being preserved at the Kew Gardens Herbarium or, in the case of specimens dealt with by outside specialists, at some centre agreed on in advance.

So far the Bureau has been considered as a centre for accumulating information and a clearing house for referring such information to the proper source, and as a centre for the systematic and cultural study of injurious fungi and an agency for getting the parasitic fungus flora of the overseas parts of the Empire worked out.

Nothing has been said about the prosecution of original research into the diseases of plants. The diseases with which we are concerned are those occurring in the distant parts of the Empire, and I hold strongly the view that true pathological research can only be done on the spot, where living clinical material is available. But I hope that the Bureau will become a place to which the overseas worker will naturally gravitate when in England on leave or otherwise, and every effort will be made to provide him with well-equipped laboratories where he can continue the study of problems in which he is interested, in directions which can be done at a distance from the crop concerned, and which can be checked and controlled by his own first-hand knowledge of the local conditions. I hope research work of various kinds will go on at the Bureau, but I hope equally that it will never be believed that the Bureau can replace the local worker, for that is not true.

Most countries now legislate for the exclusion or control of injurious fungi. Each country has usually worked out its own methods of dealing with this question and there is need for a central clearing house which can supply authentic information regarding the practice elsewhere. I am collecting the various acts and ordinances and I hope we will be able to notify changes or give other useful assistance in connexion with this matter.

It is often difficult for the isolated worker to procure the most suitable spraying or other appliances or to keep entirely up-to-date in the practical methods of dealing with fungus diseases. Here again I think we can usefully help by keeping in touch with manufacturers and with those who are testing new methods.

Apart from the diseases of plants, there are two other branches of applied mycology to which a brief allusion may be made, the study of the diseases of animals and man caused by fungi and the study of the fungi that are of importance in technical manufactures and trades. There is a vast field in our tropical

countries as yet almost unexplored (if we except the work of Castellani) in regard to the former of these subjects and I hope we can do something to stimulate research in it, and perhaps help in its more purely mycological side. Whether the Bureau can take any active part in the study of technically important fungi or not it is as yet difficult to say, but I have already had enquiries of this nature both in India and since I joined the Bureau, and I think there is a need in this direction also which we might do something to fill.

To sum up, it seems to me that the Bureau can be most usefully engaged if it has amongst its functions:

(1) The accumulation and distribution of information on all matters concerning the diseases of plants caused by fungi, of interest to workers in the overseas parts of the Empire.

(2) The publication of a periodical abstracting journal on the lines of *The Review of Applied Entomology*.

(3) The formation of a good reference library, especially of original papers in the reprint or "separate" form which will be available for issue on loan.

(4) The organization of a system for securing reasonably prompt identification of injurious fungi.

(5) The critical study of parasitic fungi which are at present the subject of confusion, such study to be in large part based on cultural methods; and the arrangement of facilities for the supply of authentically named cultures to overseas workers.

(6) The formation of a good working herbarium of parasitic fungi, with larger specimens and photographs illustrating diseases not known in this country; and the supply of named collections to other institutes and individuals.

(7) The provision of laboratory facilities to enable overseas workers to continue work, in problems in which they are interested, when in England.

(8) The organization of a central agency from which up-to-date information on such matters as legislation against plant diseases caused by fungi and recent progress in methods of control by spraying and the like can be supplied.

(9) The stimulation, as opportunity arises, of the study of other branches of applied mycology, such as those referred to above as being of interest in medicine and technology.

AN INVESTIGATION OF SOME TOMATO DISEASES.

By F. T. Brooks, M.A. and G. O. Searle, B.Sc.

In January 1913 a paper(2) was published by the senior author and another giving an account of a disease of tomatoes, isolated from the fruit and stems of plants grown out-of-doors.

This disease was identified by the late Mr Massee, as "*Ascochyta citrullina* C. O. Sm., the conidial form of *Mycosphaerella citrullina* Gross." which was also the name given by this authority(9) to the fungus causing an epidemic disease ("canker") of tomato stems in glass houses. In recent years this disease has been infrequent in English tomato houses, but it appeared in epidemic form in Holland during 1919 where it has been described by Schoevers(14) under the same name.

During the years 1911 to 1919 one of the writers collected various forms of fruit rots of tomatoes, and isolated the causal fungi. In August 1919 a detailed examination of these organisms was commenced and it seems desirable to place on record the results of this investigation obtained to date. During the early part of the joint investigation a few additional forms were collected by the junior author and included with the others.

Certain cultures and herbarium specimens were also obtained from various sources, and it will be convenient to tabulate here the origin of all the material used.

A. Phoma destructiva (Plowr.) C. O. Jamieson(7). This was an authentic culture obtained from the Department of Agriculture, Washington, D.C., in the summer of 1916 through the kindness of Dr C. L. Shear.

B. A culture of a pycnidial form of fungus from a rotten out-door tomato fruit collected at Merton, on September 17th, 1915.

C. A culture of a fungus showing both a pycnidial form of fructification and also spores of an *Alternaria* type on the same mycelium, obtained from a rotten tomato fruit collected at Bristol on January 25th, 1916. This fruit was one of a number purchased at a shop.

D. Colletotrichum phomoides (Sacc.) Chest. This was an authentic culture obtained from New York originally, but it was passed through tomato fruits and re-isolated in the autumn of 1915.

E. A culture of a pycnidial form of fungus from a rotten

tomato found lying on the ground at the Cambridge University farm on October 5th, 1916.

F. A culture of a pycnidial form of fungus from a tomato fruit, partly green, partly rotten, found at the same time and place as *E*.

G. A culture of a pycnidial form of fungus from a half-rotten tomato fruit collected at the same place and time as *E* and *F*, and only differing from them in that no pycnidia developed until it had been kept for some days in the laboratory. This culture was found to produce pycnidia and spores very sparingly and was later discarded as it was not found possible to obtain a single-spore culture from it. In the preliminary examination no difference from *E* and *F* could be detected, except that the spores were generally slightly smaller.

H. A culture of a pycnidial form of fungus from a rotten tomato (one of seven) collected in a garden at Cambridge, November 2nd, 1916.

I. This form was discarded.

J. A culture of a pycnidial form of fungus from a rotten half-ripe tomato collected at Cambridge, September 1918.

K. A culture of a *Gloeosporium* or *Colletotrichum* from a rotten half-ripe tomato collected at Cambridge, September 1918.

K 2. A culture of a *Gloeosporium* or *Colletotrichum* which appeared in the laboratory on an apparently sound ripe tomato, which had been inoculated with "A" in October 1919.

L. A culture of a pycnidial form of fungus from a diseased tomato bought in the market at Cambridge on January 17th, 1919.

M. A culture of a pycnidial form of fungus from a shrivelled tomato collected out-of-doors at Cambridge, March 1919.

N. A culture of a *Fusarium* from a rotten tomato collected at Longstowe, Cambridgeshire, August 1919.

O. This was discarded.

P. A culture of a pycnidial form of fungus from a sun-cracked tomato collected out-of-doors at Longstowe, October 1919.

Q. A culture of a pycnidial form of fungus from a rotten tomato collected out-of-doors at Longstowe, October 1919.

R. This was discarded.

S. A culture of a *Colletotrichum* from a rotten tomato collected at Cambridge, December 1919.

T. Ascochyta Pisi Lib. A culture from the Centralstelle für Pilzkulturen, Amsterdam.

U. Mycosphaerella citrullina (C. O. Sm.) Gross. An authentic culture kindly furnished by Dr C. L. Shear of the United States Department of Agriculture in the autumn of 1919. This was

originally collected at Detroit, Michigan from a cucumber grown in Florida. To date no fructifications have formed on any of the media used so that it has not been possible to make a single-spore culture.

The herbarium specimens examined for the purpose of this investigation were as follows:

1. *Mycosphaerella citrullina* on tomato stem collected at Cheshunt, June 1st, 1911, kindly supplied by Mr A. D. Cotton, Ministry of Agriculture, Herbarium No. A 14405.

2. *Mycosphaerella citrullina* on tomato stem collected at Finchley, July 1915. From the same source as No. 1, Herbarium No. A 25208.

3. *Mycosphaerella citrullina* (C. O. Sm.) Gross. on watermelon stem, collected at Lakeland, Fla., U.S.A., in April 1919, kindly sent by Dr C. L. Shear.

4. *Mycosphaerella citrullina* (C. O. Sm.) Gross. on watermelon from Florida, collected in New York market, May 1919; also sent by Dr C. L. Shear.

5. *Mycosphaerella citrullina* Gross. on tomato stem collected by A. A. Wills at Cheshunt, September 16th, 1910; in the Kew herbarium(6).

6. *Mycosphaerella citrullina* Gross. on tomato stem collected by F. Hearnum at Waltham Cross on June 14th, 1909; in the Kew Herbarium.

7. *Mycosphaerella citrullina* Gross. on the lower part of melon stem, collected by I. W. Read at Norwich, September 1912; in the Kew Herbarium.

8. *Phoma Lycopersici* Cke. on tomato stem. Collected by J. E. Vize (*circa* 1884?); in the Kew Herbarium.

9. *Diplodina citrullina* (Sm.) Gross. Collected in Brandenburg "auf trockenen Ranken von *Cucumis sativus*" by P. Vogel, December 18th, 1908; from Sydow's "Mycotheca germanica"; in the Herbarium of the British Museum.

10. *Mycosphaerella citrullina* (C. O. Sm.) Gross. on cucumber fruit collected in Florida, May 1917. Received from Dr C. L. Shear(5).

An effort was also made to obtain Plowright's type specimens of *Phoma destructiva* and *Sphaeronema Lycopersici*(9) but these were not forthcoming*.

A detailed investigation of the cultural and other characteristics of the various forms isolated was commenced in August 1919. In the preliminary cultural trials "pure cultures" were used but not "single-spore" cultures; single-spore cultures were

* We are indebted to Mr W. B. Grove for kindly searching for these specimens in Plowright's herbarium, which is now in the Botanical Department of Birmingham University.

isolated later and were used throughout the remainder of the investigation. The cultures and inoculations were made and maintained at ordinary laboratory temperatures.

PRELIMINARY INOCULATIONS AND CULTURE EXPERIMENTS.

A preliminary series of inoculations and culture experiments were carried out, using the various forms as isolated on tomato agar. Twelve forms were used, namely: *A*, *B*, *C*, *D*, *E*, *F*, *G*, *H*, *J*, *K*, *L*, *M*, which were the only ones available at the time. The following hosts and artificial media were employed with a view to obtaining a general idea of the characteristics of the various forms and to discover, if possible, some medium which would give a maximum spore formation, before proceeding to the isolation of single-spore cultures and a final comparison of the various forms.

Series A consisted of inoculations into nearly ripe tomato fruits kept in a large glass dish in the laboratory. Two cuts were made with a sterile scalpel in each fruit and a fragment of mycelium introduced from each culture. Control tomato fruits were cut but not inoculated.

In each case a rot of the fruit commenced by the fourth day, except in the controls which remained healthy. All the forms were then successfully re-isolated on to tomato agar from the fruits. Descriptions of the appearance of these fungi on tomato fruits are given later.

Series E consisted of inoculations of pieces of petiole of vegetable marrow, sterilised and kept in tubes at laboratory temperature. On this substratum all the various forms grew luxuriantly and spores were freely produced.

Series G consisted of inoculations into stems of living tomato plants in a greenhouse. Mycelium was inserted into a slit in the stem and the wound was then bound up with tin-foil. In the case of Form *L* a large canker was formed about $2\frac{1}{2}$ inches long, which spread also to the base of adjacent branches. Large numbers of pycnidia were visible, and re-isolation on to tomato agar was carried out giving Form *L* again. In all the other inoculations there was a slight discoloration of the stem, but no cankers were formed nor was there any trace of pycnidia.

Series K consisted of inoculations on to sterilised potato cores, *Series L* on to sterilised potato cores plus 1 % glycerine, and *Series M* on to potato agar; these three media were used to try to discover one which would give a uniform production of fruiting bodies of the various forms. However, none of them was particularly successful, though all the various forms developed on these media to a greater or less extent as far as the

mycelial stage was concerned. The mycelium was more scanty on potato agar than on the other two media.

Series N was undertaken to test the pathogenicity of these twelve forms on the fruit of the vegetable marrow. A large fruit was selected and vertical slits about one inch apart were made round the circumference, into which the various forms were inoculated. In no case did a positive infection occur.

A few other preliminary experiments were made and will be briefly mentioned here.

Inoculations with forms *C*, *J*, and *M* were made into pears under bell jars in the laboratory, pears with sterile cuts and tomato fruits with inoculations of *C*, *J* and *M* being used as controls. Typical rots with abundant pycnidia were formed on the control tomato fruits, but in the pears no rot was caused by Form *C*, whilst Forms *J* and *M* both formed large soft brown rots although no mycelium nor pycnidia showed on the surface.

Preliminary experiments were then tried for the purpose of indicating whether the various forms were wound or non-wound parasites of tomato fruits. It was found that the finest prick on the surface was sufficient to allow the entry of the fungus when spores were sown on the surface, but infection never resulted when spores were sown on the uninjured surface, even when spores were sown in a drop of 10 % sugar solution to assist germination or when mycelium was placed on the surface of the fruit in a fragment of tomato agar.

Spore suspensions of Forms *C* and *H* were sprayed over tomato plants about two feet high in the greenhouse, but no infection nor leaf spotting took place.

ISOLATION OF SINGLE-SPORE CULTURES AND EXPERIMENTS THEREWITH.

During October, November, and December 1919, single-spore cultures of all the forms were made. Each form was passed through the tomato fruit and back on to tomato agar, single-spore cultures being established on the latter by the dilution method. As soon as single-spore cultures of all the forms had been obtained, the following fourteen series of inoculations and culture experiments were carried out to obtain some idea of the characters of the various forms on different media with a view to their systematic arrangement.

All the forms were not used in every series, sometimes owing to lack of material. The following table shows in brief the results of these experiments.

Table I. *Cultures on tomato agar were always used.*

Host or medium used	Forms used	Results
(1) Sterilised tomato stems in tubes	All except *G*, *S* and *U*	Very profuse growth of mycelium in all; fruiting bodies generally formed
(2) Tomato plants; needle pricks made in stem	*B*, *C*, *D*, *E*, *H*, *K2*, *L* and *T*	Only *L* took; canker encircled the stem which collapsed; pycnidia formed
(3) Potato agar	All except *G*, *S* and *U*	Mycelium scanty. Fruiting bodies usually formed sparingly
(4) Melon plants in greenhouse. Needle pricks made in stem	*B*, *D*, *K2*, *L*, *T*	No infection
(5) Cucumber plants in greenhouse. Needle pricks made in stem	*B*, *L*, *T*	No infection
(6) Carrots in the laboratory. Needle prick inoculations	*A*, *B*, *D*, *J*	No infection
(7) Apples (Cox's Orange) in the laboratory. Needle prick inoculations	*B*, *J*, *L*	No infection
(8) Potatoes in the laboratory. Needle prick inoculations	*C*, *E*, *J*, *L*	*L* formed a dry sunken canker with typical pycnidia and spores. *C*, *E*, *J* without effect
(9) Sterilised potato cores	All except *G*, *S* and *U*	Generally a profuse growth of mycelium with a fair number of fruiting bodies
(10) Green grapes kept in an incubator at 27° C. Needle prick inoculations	All except *G* and *S*	No infection
(11) Dox's medium (5) (30 grms. cane sugar per litre)	All except *G*, *S* and *U*	Mycelium generally profuse and dark coloured, quite obscuring the fruit bodies
(12) Dox's medium (15 grms. cane sugar per litre)	All except *G*	Mycelium less profuse, lighter colour, fruiting bodies plentiful
(13) Dox's medium (7·5 grms. cane sugar per litre)	All except *G*	Mycelium less profuse, fruiting bodies plentiful
(14) Green tomato fruits in the laboratory. Needle prick inoculations	All except *G* and *S*	All formed typical rots except *U*

In the course of these experiments it was soon found that these forms of fungi took on great differences in growth-characteristics according to the medium used; with the exception of type *C* it was impossible to pick out these forms by any feature which was constant throughout all the media and hosts tried.

The conclusion was reached that it was absolutely necessary to use a purely artificial medium like Dox's, if any attempt was to be made to put on record differences between such closely related species or varieties as were being used, which would have value for other workers.

In using Dox's medium it was found that the normal amount of cane sugar, *i.e.* 30 grms. per litre, produced a too profuse mycelial growth, so that fruit bodies, specially of the pycnidial type, were obscured and such details as the colour of the spore mass could not be determined.

The amount of sugar was therefore first modified to 15 grms. per litre and later to 7·5 grms. per litre. This latter medium appeared to give the most satisfactory results.

On duplicating the whole series on the medium containing 7·5 grms. sugar no appreciable difference could be discerned between the two tubes of each form, an effect which was not seen when working with other media such as tomato agar.

The formula used in this modification of Dox's medium was as follows:

Magnesium sulphate	0·5 grm.
Potassium acid phosphate ...	1·0 ,,
Potassium chloride	0·5 ,,
Ferrous sulphate	0·01 ,,
Sodium nitrate	2·0 grms.
Cane sugar	7·5 ,,

Made up to 1000 c.c. with 2 % agar.
The acidity was + 13·6.

DESCRIPTION OF THE MACROSCOPIC CHARACTERS OF THE VARIOUS FORMS ON TOMATO FRUITS.

The following gives the appearance of these fungi on tomato fruits about ten days after inoculation:

Form A. A black spot roughly circular about ½–1 inch in diameter, slightly sunken towards the circumference, generally raised in the centre at the point of inoculation. Shades off in colour towards the uninjured part of the fruit. Very numerous black pycnidia aggregated round the centre and erumpent through the epidermis of the fruit, giving the surface a roughly punctate, carbonaceous appearance.

Form B. Large brown spot, with numerous brown pycnidia erumpent through the epidermis of the fruit.

Form C. Large brownish black spot, about one inch in diameter, raised in the centre and sunken towards the circumference. Very numerous, densely gregarious pycnidia, varying from brown to black in colour, covered with dull greyish pink, slimy, spore masses.

Form D. Watery-looking, rugged canker about one inch in diameter, entirely covered with closely aggregated black acervuli, surrounded by a circle of younger acervuli covered with pink spores.

Form E. Large, light brown spot, not raised nor depressed, numerous light brown pycnidia.

Form F. Same appearance as *E* but the pycnidia of a somewhat darker brown.

Form H. Same appearance as *F.*

Form J. Large, brownish spot, rather sunken below the remainder of the surface, numerous pycnidia varying from brown to black.

Form K. Large, rather watery-looking spot, completely covered with pink cushions of spores, later becoming blackish.

Form K 2. Similar to *K*, but later the pink cushions (acervuli) became black and the appearance was then similar to *D.*

Form L. Large canker covered with black pycnidia.

Form M. Large, rugged, brown canker covered with brown pycnidia.

Form N. Large canker covered with white mycelium and masses of pink *Fusarium* spores.

Form P. Large brown cankered spot, rather rugged surface, covered with brown pycnidia.

Form Q. Smooth, black spot, almost shiny surface, numerous pycnidia scarcely erumpent through the epidermis of the fruit.

Form S. Black acervuli formed with typical, pointed setae and large numbers of spores.

Form T. Large spot about 1½ inches in diameter, self coloured, not soft, no visible pycnidia but very numerous pink tendrils of spores projecting through the surface from pycnidia evidently subcutaneous.

Form U. The fungus spread only to a very slight extent when inserted into tomato fruits, and no fructifications were formed.

It would make this paper of undue length to include a full macroscopic description of these forms on all the different media used. For one thing, the composition of such media as tomato agar and potato agar varies considerably in different batches, and undoubtedly the macroscopic characters of the cultures vary with changes in the medium, so that the characters shown on a medium such as tomato agar or potato agar would probably not be of great value to other investigators. In the following description, therefore, only the microscopic characters on the third modification of Dox's medium, i.e. the one containing 7·5 grms. cane sugar per litre, are given, with occasional notes on special points shown on other media, since Dox's medium, being of a synthetic nature, can be duplicated at will with the knowledge that future batches will be of very close comparative chemical composition with the medium from which the present diagnoses were made.

MACROSCOPIC CHARACTERS OF THE VARIOUS FORMS ON DOX'S MEDIUM MODIFIED TO CONTAIN 7·5 GRMS. CANE SUGAR PER LITRE, WITH OCCASIONAL NOTES ON CHARACTERISTICS SHOWN BY THE FORMS ON OTHER MEDIA.

Form A. Aerial mycelium fairly plentiful, varying from white to grey. Medium not coloured, submerged mycelium hyaline. Pycnidia very numerous, black, small, more closely aggregated towards the middle of the culture, semi-erumpent. No visible spore mass. This form generally produced pycnidia very sparingly. The quantity of mycelium varied greatly on different media; on potato agar it was very slight with a few light brown pycnidia, whilst on Dox's medium with 30 grms. sugar per litre, the mycelium was very profuse and dark olive green in colour.

Form B. Aerial mycelium fairly plentiful, generally white but varying to light grey in colour, submerged mycelium hyaline. Pycnidia numerous, scattered, varying greatly in size, generally in the aerial mycelium, sometimes on the surface of the medium, black in colour. With potato agar, on the other hand, the mycelium was dark coloured and largely submerged in the medium, and numerous dark coloured appressoria were formed towards the edge of the culture; on tomato agar a dirty yellow-coloured spore mass was noticeable and on Dox's medium with 30 grms. sugar the mycelium was very profuse and almost black.

Form C. Aerial mycelium very slight, fulvous brown to grey. Pycnidia very numerous, chocolate brown in colour with a few pink spore masses. Pycnidia apparently seated on the surface of the medium. On Dox's medium with 15 grms. sugar per litre, the spore masses were very conspicuous as pink spots which coalesced all over the surface of the medium, whilst at the top and bottom of the culture were dark brown bands of aerial mycelium bearing the *Alternaria* form of spores; on potato agar, on the other hand, both mycelium and pycnidia were scanty, the latter being light brown in colour and almost entirely aggregated along the original inoculation streak. All the cultures were similar in showing scanty mycelial growth and early formation of pycnidia, the first being usually formed within 48 hours of the culture being made. The *Alternaria* form invariably appeared later and upon the drier portion of the culture. Sowings of the *Alternaria* spores were made and these produced pycnidia first and *Alternaria* later. Cultures made from single pycnospores also formed spores of *Alternaria* as well as pycnidia.

Form D. Aerial mycelium grey, tending to become matted.

Pink tinge at the surface of the medium. Submerged mycelium slight and hyaline. Black acervuli large and scattered, with numerous smaller black bodies, apparently sterile acervuli, which were scattered throughout the medium. On other media the cultures only differed in the numbers of acervuli.

Form E. Aerial mycelium very scanty, white; submerged mycelium hyaline, scanty; pycnidia and spore masses very numerous and both of a light brown or straw colour. Other cultures showed variations in the colour of the mycelium, but the pycnidia were always light brown in colour.

Form F. Aerial mycelium fairly plentiful, white, tending to be floccose. Pycnidia very numerous, light brown, particularly aggregated at the bottom of the culture. Spore masses infrequent, light yellowish brown in colour. In this case, the colour of the pycnidia varied greatly, as on tomato agar and sterilised tomato stem the pycnidia were almost black; this was not a matter of age of culture since, on Dox's medium, the pycnidia were still light brown in colour at the end of eight months.

Form H. Aerial mycelium, white, scanty at the top of the culture but denser at the base. Pycnidia numerous, dark brown, mainly aggregated at base of culture, on surface of medium or in aerial mycelium, larger than in *E* and *F*. Spore masses few and light brown. Fairly similar characteristics were shown on the other media, the mycelium varying, however, from white to dark grey.

Form J. Aerial mycelium plentiful, white. Pycnidia few, large, brown, tending to be confluent; spore masses light brown to yellow. Pycnidia partly submerged in the medium. Generally, only few pycnidia were formed, except on potato cores and tomato stems, on which the number was large and their colour black.

Form K. Aerial mycelium plentiful, white to dark brown-grey. Large aggregations of very dark-coloured submerged mycelium. No trace of fructifications. This form produced very few spores and in artificial cultures spores appeared only early in the development of the fungus and not on a distinct acervulus—at least no black acervuli were visible as in Form *D*; on tomato fruits the spores were aggregated on acervuli and were numerous, but the same dense cushion of mycelium covered with spores was not observed in any culture.

Form K 2. This culture was similar to *K*, except that the mycelium was more scanty. Here again no proper acervuli were formed in culture except in one on tomato agar where a few black acervuli were visible. The sporing stage, as in *K*, could be seen from the pink tinge taken on by the mycelium in the early stages.

Form L. Aerial mycelium, white, scanty, evanescent, adpressed to the medium. Pycnidia exceedingly numerous, brown, with light brown spore masses, generally half-submerged in the medium, some wholly submerged. This was a very constant form on all media, always showing very scanty mycelium and exceedingly numerous brown pycnidia.

Form M. Aerial mycelium plentiful, tending to be matted, greyish white. Pycnidia fairly numerous, scattered at the top of the culture and aggregated towards the bottom, brown to light brown in colour, with yellow brown spore masses. On other media the production of pycnidia was slight except on sterilised tomato stems, where they were very numerous and black in colour.

Form N. Aerial mycelium very scanty, evanescent, white. Large, confluent, salmon pink spore masses. Mycelium was always rather scanty except on potato cores and sterilised tomato stems, but the cultures were very distinct by reason of the large confluent masses of *Fusarium* spores.

Form P. Aerial mycelium very profuse, white, matted. Pycnidia very few, scattered, brown, large. On different media the pycnidia varied from brown to black.

Form Q. Aerial mycelium fairly plentiful, white, closely adpressed to the medium. Pycnidia very few, brown. Spore formation very sparse on all media.

Form S. Aerial mycelium very scanty and almost entirely evanescent. Acervuli very numerous, black, scattered all over the culture. In earlier stages the medium took on a pinkish tinge.

Form T. Aerial mycelium very scanty and evanescent, white. Pycnidia numerous, yellowish brown, later a red brown, entirely covered with profuse, pink spore masses. The colour of the pycnidia and spore masses varied considerably on various media; pycnidia dark brown on potato agar, light brown on tomato agar; spore masses dirty pink to salmon colour on tomato agar, brick red on potato cores.

Form U. Aerial mycelium profuse, grey, adpressed to the medium. No fructifications were produced by this form on any medium, which was disappointing as it was the only culture of an authentic *Mycosphaeralla citrullina* and so was important for comparative purposes.

Before discussing the microscopic characters of the various forms and comparing them with the herbarium and other material obtained, it will be convenient to divide them into groups.

The first and most important section, Group *A*, contains all the forms having a pycnidial type of fructification and probably belonging either to the genus *Phoma* or to the genus *Diplodina*.

This GROUP *A* includes the following forms:

Form A: which is an authentic specimen of *Phoma destructiva* (Plowr.) C. O. Jamieson, from America.

Form B.

Form C: which possesses an *Alternaria* form of spore as well as a pycnidial stage.

Forms E, F, H, J.

Form L: which is pycnidial but shows differences from the other forms in its wider infective powers and greater percentage of septate spores.

Forms M, P, Q.

Form T: which is a specimen of *Ascochyta Pisi* Lib.

Form U: no fructifications were formed by this.

GROUP *B* consists of those forms which can be placed either in the genus *Colletotrichum* or *Gloeosporium*, and includes:

Form D: which is an authentic culture of *Colletotrichum phomoides* (Sacc.) Chester from America.

Forms K, K 2 and *S.*

GROUP *C* consists only of Form *N* which is a typical species of the genus *Fusarium.*

In studying the various forms of Group *A* it was found that these showed great variability in characters which are generally looked upon as specific, such as size of spores, septation of spores, guttulation and shape of spores, and one was forced to the conclusion that a number of so-called species in genera like *Phoma*, *Ascochyta* and *Diplodina*, are nothing more than varieties of one and the same fungus. In fact, it is difficult to see how a final decision is to be made in many cases unless the investigator has the opportunity of carrying out a large number of cultural trials on artificial media and also cross inoculations on to various hosts. A comparison of the microscopic characters found in the pycnidial forms included under Group *A* will now be made:

MICROSCOPIC CHARACTERISTICS OF THE VARIOUS FORMS INCLUDED IN GROUP *A* (PYCNIDIAL FORMS) ON TOMATO FRUITS AND CULTURE MEDIA.

Form A.

	Description given by Miss Jamieson (q.v.)	Description of authors' cultures
PYCNIDIA.	Scattered to aggregate, most abundant towards centre of spot, subcutaneous later erumpent, glabrous, brownish black, subglobose, slightly papillate,	Pycnidia varying greatly in size, sometimes single, sometimes compound with two or more ostioles (sometimes as many as four). Pycnidia

	Description given by Miss Jamieson (q.v.)	Description of authors' cultures
	not beaked, ostiolate (usually one sometimes two pores), 30–350 μ in diameter. Pycnidial wall thin, outer cells brown, inner cells hyaline; delicate filiform basidia arising from inner cells.	usually globose but irregular shapes seen, light yellowish brown, ostiole surrounded by a dark circle. Erumpent through the epidermis.
PYCNOSPORES.	Issue in coils through ostiolum forming a shiny flesh-coloured exudate...hyaline.	Issue in coils through the ostiolum. Hyaline.
SHAPE.	Sub-cylindrical to sub-globose, rarely tapering.	Sub-cylindrical with rounded ends, occasionally slightly asymmetrical.
SEPTATION.	Continuous.	Non-septate.
GUTTULATION.	2-guttulate.	Rarely faintly biguttulate.
SIZE.	2·8 μ–8·5 μ × 1·7 μ–3·4 μ.	3·5 μ–5·5 μ × 2 μ–3 μ. Very uniform in size.

Form B.

PYCNIDIA.	Pycnidial characters as to shape, size and colour varied so much as to seem unreliable for diagnostic purposes and are omitted in this and other forms.
PYCNOSPORES.	Issue in coils through the ostiolum. Hyaline.
SHAPE.	Ovate, usually slightly asymmetrical on one side and often slightly pointed at one end.
SEPTATION.	Non-septate.
GUTTULATION.	Bi-guttulate.
SIZE.	3·5 μ–7·5 μ × 2 μ–3·5 μ (20 measurements). Dark, thick-walled appressoria were also formed.

Form C.

PYCNOSPORES.	Issue in coils through ostiolum. Hyaline.
SHAPE.	Ovate with a tendency to pointed ends.
SEPTATION.	Non-septate.
GUTTULATION.	Very faintly biguttulate, except on Dox's medium, where they were strongly biguttulate and the average size was larger.
SIZE.	3 μ–7·5 μ × 2 μ–3·5 μ (20 measurements). An *Alternaria* form of spore was borne on the same mycelium, a large brown-coloured multi-septate spore of greatly varying shape and size. There were also numerous, thick-walled, dark coloured spore-like bodies averaging 8 μ × 4 μ round the edges of the cultures; these were not observed to germinate or become detached from the mycelium and they were taken to be a kind of appressorium formed under cultural conditions.

Form E.

PYCNOSPORES.	Issue in coils through ostiolum. Hyaline.
SHAPE.	Irregular, usually ovate to cylindrical, usually with rounded ends, but sometimes one end pointed, occasionally slightly curved.

Septation.	Usually non-septate, but about 10–20 % 1-septate, generally slightly constricted at the septum.
Guttulation.	Very rarely bi-guttulate.
Size.	3·5 μ–9 μ × 2 μ–3·5 μ non-septate. 7·5 μ–11 μ × 3 μ–3·5 μ 1-septate (20 measurements).

Form F.

Pycnospores.	Issue in coils through ostiolum. Hyaline.
Shape.	Ovate to cylindrical with rounded ends, occasionally slightly curved.
Septation.	Usually non-septate, but 5 % of the spores from a tomato agar culture were 1-septate, and on Dox's medium between 5 % and 10 % were 1-septate. Septate spores scarcely, if at all, constricted at the septum. In this form a spore mass which had been extruded some time from a pycnidium showed up to 50 % of the spores septate.
Guttulation.	About 40 % of the spores were bi-guttulate.
Size.	4 μ–8·5 μ × 2·5 μ–4 μ non-septate. 7 μ–9 μ × 3 μ–3·5 μ 1-septate (20 measurements).

Form G.

Discarded.

Form H.

Pycnospores.	Issue in coils through ostiolum, hyaline.
Shape.	Ovate to sub-cylindrical, all very uniform in shape and size.
Septation.	Non-septate.
Guttulation.	Bi-guttulate.
Size.	3·5 μ–6·5 μ × 2·5 μ–3·5 μ (20 measurements).

Form J.

Pycnospores.	Issue in coils through ostiolum, hyaline.
Shape.	Ovate to cylindrical with rounded ends, occasionally slightly curved.
Septation.	Usually non-septate, about 5–10 % 1-septate, scarcely, if at all, constricted at the septum. Spores from a spore mass on Dox's medium were about 30 % 1-septate.
Guttulation.	Occasionally faintly bi-guttulate.
Size.	3·5 μ–9 μ × 2·5 μ–3·5 μ non-septate. 8 μ–10·5 μ × 3 μ–4 μ 1-septate (20 measurements).

Form L.

Pycnidia.	Sometimes malformed and assuming a tubular form a millimetre or more long in culture. Frequently with more than one ostiole.
Pycnospores.	Issue in coils through ostiolum, hyaline.
Shape.	Cylindrical, rounded ends, some slightly curved, some ovate. Sizes varying considerably.
Septation.	About 40 % 1-septate, the remainder non-septate. Always constricted at the septum. On potato agar up to 80 % 1-septate.
Guttulation.	Occasionally bi-guttulate.
Size.	4·5 μ–11 μ × 2·5 μ–5 μ non-septate. 7·5 μ–12·5 μ × 3·5 μ–4·5 μ 1-septate (20 measurements).

Form M.

Pycnospores.	Issue in coils through ostiolum, hyaline.
Shape.	Ovate to sub-cylindrical, rounded ends, very varied in size and shape.
Septation.	Usually non-septate, about 20 % 1-septate and generally constricted at the septum. Occasionally 2-septate.
Guttulation.	No guttules.
Size.	4·5 μ–12 μ × 2 μ–4 μ non-septate. 9 μ–17 μ × 2·5 μ–5 μ 1-septate. 15 μ × 3·5 μ (20 measurements).

Form P.

Pycnospores.	Issue in coils through ostiolum, hyaline.
Shape.	Ovate to sub-cylindrical with rounded ends, occasionally slightly curved.
Septation.	Usually non-septate, about 10 % 1-septate, not constricted at the septum. Percentage of septate spores rapidly increases with age.
Guttulation.	Very occasionally a single guttule.
Size.	3·5 μ–10 μ × 2 μ–4 μ non-septate. 8 μ–14 μ × 3 μ–4 μ 1-septate (20 measurements).

Form Q.

Pycnospores.	Issue in coils through ostiolum, hyaline.
Shape.	Ovate to cylindrical, one end usually and sometimes both ends pointed.
Septation.	Non-septate.
Guttulation.	Generally bi-guttulate.
Size.	4 μ–8 μ × 2·5 μ–3·5 μ (20 measurements).

Form T.

This was a specimen of *Ascochyta Pisi* Lib.

Pycnospores.	Issue in coils through ostiolum, the coil often attaining a length of two or three millimetres. Hyaline, often very vacuolate, but non-vacuolate in perfectly fresh spores.
Shape.	Cylindrical with rounded ends, often slightly curved.
Septation.	95 % 1-septate, occasionally 2 or 3-septate, not constricted at the septum, except in perfectly fresh spores which were slightly constricted.
Guttulation.	Indefinite.
Size.	10·5 μ–17·5 μ × 2·5 μ–4·5 μ 1-septate. 14·5 μ × 3·5 μ 2-septate. 24 μ × 4·5 μ 3-septate. 8 μ × 3 μ non-septate (20 measurements).

The systematic position of species of the genera *Phoma*, *Ascochyta*, and *Diplodina* is difficult to determine.

The chief difference between the genera *Phoma* and *Diplodina* is that, according to systematists, the spores of *Phoma* are non-septate and those of *Diplodina* 1-septate.

A study of the herbarium specimens does not tend to make matters easier as will be seen by the following descriptions:

Herbarium Specimen 1. MYCOSPHAERELLA CITRULLINA (reputed) on tomato stem, England (only pycnidial stage present).

PYCNOSPORES.	Ejected in coils from ostiolum. Spores rather shrunken and mis-shapen through age.
SHAPE.	Very irregular.
SEPTATION.	Usually non-septate, about 20 % 1-septate: usually constricted at the septum.
GUTTULATION.	About 50 % bi-guttulate.
SIZE.	5 μ–11 $\mu \times 3$ μ–4 μ non-septate. 9 μ–10·5 $\mu \times 3$ μ–4 μ 1-septate.

Herbarium Specimen 2. MYCOSPHAERELLA CITRULLINA (reputed) as No. 1 (only pycnidial stage present).

PYCNOSPORES.	Ejected in coils from ostiolum. Hyaline.
SHAPE.	Irregular, often constricted at the centre, some slightly curved, some pear-shaped.
SEPTATION.	Usually non-septate, only about 5 % 1-septate.
GUTTULATION.	Occasionally indistinctly bi-guttulate.
SIZE.	4 μ–10 $\mu \times 2{\cdot}5$ μ–3·5 μ non-septate. 8 μ–10·5 $\mu \times 3{\cdot}5$ μ 1-septate.

Herbarium Specimen 3. MYCOSPHAERELLA CITRULLINA (C. O. Sm.) Gross., on water-melon stem (pycnidial stage) from America.

PYCNOSPORES.	Ejected in coils through the ostiolum, the pore of the ostiolum seemed narrower than usual and the spores were ejected in a coil only three or four spores wide. Spores hyaline.
SHAPE.	Very regular, cylindrical, rounded at the ends, very rarely slightly curved.
SEPTATION.	Usually non-septate, rarely faintly 1-septate (about 10 %).
GUTTULATION.	Indefinite.
SIZE.	5 μ–14 $\mu \times 2{\cdot}5$ μ–5 μ non-septate. 10 μ–13 $\mu \times 3{\cdot}5$ μ–4 μ 1-septate.

Herbarium Specimen 4. MYCOSPHAERELLA CITRULLINA (C. O. Sm.) Gross., on water-melon, same source as No. 3 (pycnidial stage).

PYCNOSPORES.	Ejected in coils through ostiolum, hyaline.
SHAPE.	Cylindrical, rounded ends, sometimes slightly curved.
SEPTATION.	Always 1-septate, occasionally 2-septate.
GUTTULATION.	Generally bi-guttulate.
SIZE.	10·5 μ–17 $\mu \times 3$–3·5 μ 1-septate. 14 μ–15 $\mu \times 3{\cdot}5$ μ–4 μ 2-septate.

Herbarium Specimen 5. MYCOSPHAERELLA CITRULLINA Gross. (reputed), on tomato stem, England; in the Kew Herbarium (pycnidial stage only).

PYCNOSPORES.	Ejected in coils through the ostiolum, hyaline.
SHAPE.	Cylindrical, rounded ends, regular. Some very slightly curved.
SEPTATION.	Usually non-septate, about 20 % 1-septate, not constricted at the septum.
GUTTULATION.	No guttules.
SIZE.	4 μ–10 $\mu \times 2{\cdot}5$ μ–3·5 μ non-septate. 8·5 μ–10 $\mu \times 3$ μ–3·5 μ 1-septate.

Herbarium Specimen 6. MYCOSPHAERELLA CITRULLINA (reputed), on tomato stem, England; in the Kew Herbarium (pycnidial stage only).

PYCNOSPORES.	Ejected in coils through the ostiolum, hyaline.
SHAPE.	Mainly cylindrical with rounded ends, but irregularly shaped and curved, spores numerous.
SEPTATION.	About 60 % 1-septate, sometimes slightly constricted at the septum.
GUTTULATION.	Few spores bi-guttulate, a few one-guttulate.
SIZE.	6 μ–10 μ × 2·5 μ–4 μ non-septate. 7·5 μ–11 μ × 3 μ–4 μ 1-septate.

Herbarium Specimen 7. MYCOSPHAERELLA CITRULLINA (reputed), on lower part of melon stem, England, in the Kew Herbarium (pycnidial stage only).

PYCNOSPORES.	Very few spores were obtained from this specimen and the mode of ejection from the pycnidium could not be determined.
SHAPE.	Cylindrical with rounded ends.
SEPTATION.	All except 3 spores (15 was total number seen) were very faintly 1-septate, no constriction at septum.
GUTTULATION.	No guttules.
SIZE.	8 μ–10 μ × 2·5 μ–3·5 μ 1-septate. 7 μ–9 μ × 3 μ non-septate.

Herbarium Specimen 8. PHOMA LYCOPERSICI Cke., on tomato stem, England. This was Cooke's type specimen in the Kew Herbarium.

PYCNIDIA.	Pycnidia brown, roughly spherical to triangular, average diameter 170 μ. Ostioles usually 1, sometimes more. A few compound pycnidia seen. Only a few spores were obtained.
PYCNOSPORES.	Hyaline, but the mode of ejection from the pycnidium could not be determined.
SHAPE.	Cylindrical with rounded ends, very regular.
SEPTATION.	90 % 1-septate.
GUTTULATION.	No guttules.
SIZE.	8 μ–12 μ × 2·5 μ–4 μ 1-septate. 7 μ–11 μ × 2·5 μ–3·5 μ non-septate (20 measurements).

Herbarium Specimen 9. DIPLODINA CITRULLINA (reputed), on dried stems of cucumber, from Germany, 1908; in the Herbarium of the British Museum.

PYCNIDIA.	Pycnidia light brown with a darker band surrounding the lighter-coloured ostiole.
PYCNOSPORES.	Hyaline, but the mode of ejection from the pycnidium could not be determined.
SHAPE.	Not cylindrical.
SEPTATION.	About 40 % 1-septate.
GUTTULATION.	No guttules.
SIZE.	5–9 μ × 2·5 μ–3·5 μ.

Herbarium Specimen 10. MYCOSPHAERELLA CITRULLINA (C. O. Sm.) Gross., on cucumber fruit collected in Florida, 1917. This was the perithecial stage, but no spores were obtainable from this material.

From a study of these herbarium specimens it is apparent that even these do not conform with the usually accepted ideas of the genera *Phoma, Ascochyta* and *Diplodina*. In fact, taking into consideration the lack of any perithecial stage it would seem that the two herbarium specimens from the Ministry of Agriculture (No. 1 and No. 2) and those from the Kew Herbarium (Nos. 5, 6, and 7) should certainly not be placed in the genus *Mycosphaerella*.

The circumstances point to the fact that, contrary to the usually accepted idea, the species *Mycosphaerella citrullina* (C. O. Sm.) Gross.(6) has not yet been found in England. It should therefore be deleted from the list of British species known at present. The cultural characters and general behaviour of authentic specimens of *Mycosphaerella citrullina* from America, do not agree with any of the fungi isolated from tomatoes in this country.

Cooke's fungus, *Phoma Lycopersici*, should certainly be placed in a different genus (*Diplodina*) as nearly all the spores are septate.

Taking into consideration the extreme variability of the genera *Phoma* and *Diplodina* we have classified the forms under investigation in the following manner, although it is doubtful if a sharp line can be drawn between Series 1 and Series 2:

Series 1.

True *Phoma destructiva* (Plowr.) C. O. Jamieson as defined by *Form A*, an authentic culture.

Forms B, H and Q.

So far in this country these forms have only been found on tomato fruits, although in America this fungus is able to cause also a disease of the leaves and stems.

Series 2.

Intermediate in type between *Phoma* and *Diplodina*. Septation of spores variable, but there are always some spores septate and the spores are usually larger than in Group *A*.

Forms E, F, J, M, P, L.

Included in this group also are herbarium specimens 1, 2, 5, 6, 7 and 8. These forms have been found both on the fruit and on the stem of tomato plants. They differ considerably as regards pathogenicity to the stems under experimental conditions.

These forms are closely allied to one another and probably only represent strains of the same aggregate species. In the present state of our knowledge and methods of analysis, it is considered advisable to attempt to give names only to aggregate species of fungi and not to the smaller elementary species or strains of which the aggregate species consist. It has long been recognised by those who grow fungi in pure culture that many species show numerous forms which can only be differentiated one from the other by minor cultural characters, but under present conditions mycological systematy would become altogether too unwieldly if attempts were made to name these different cultural forms.

It is proposed to place this group of forms as well as herbarium specimens Nos. 1, 2, 5, 6, 7 and 8, in the genus *Diplodina*. It has already been pointed out that, as regards these fungi, the generic distinction between *Phoma* and *Diplodina* has broken down, but in view of the considerable percentage of septate spores in the pycnidia, *Diplodina* has been chosen as the generic name. The name *Ascochyta* is not used as the pycnidia do not occur in spots. Two species of *Ascochyta* have been recorded on decaying tomato leaves (13), *A. Lycopersici* Brun. with spores constricted at the middle, and *A. socia* without median constriction. These species have not been seen by us and have not yet been recorded in Britain. *A. Lycopersici* Brun. may be identical with the fungus now under consideration, but if so, it is preferable to place it in the genus *Diplodina*. Cooke's name *Phoma Lycopersici* (4) is deleted. Plowright's *Sphaeronema Lycopersici* (12) found on tomato fruits may be identical with this, but it has not been possible to obtain the original specimen. It is doubtful whether Plowright* placed his fungus in the right genus as the neck of the pycnidium as figured in his paper is extremely short, and there is no mention of it in the diagnosis. The spores are about the same size as in our forms and the absence of septation is not remarkable. In view of these considerations and of the apparent loss of the type specimen, it seems advisable also to delete the name *Sphaeronema Lycopersici*.

In considering the systematic position of this fungus, Mr J. Ramsbottom of the British Museum—to whom we are much indebted for help in the matter of nomenclature—called our attention to the description of *Diplodina Lycopersici* Hollós in Saccardo's Sylloge Fungorum (13). Although it has not been

* Since this was written, Mr W. B. Grove informs us that Plowright's idea of *Sphaeronema* depended upon the presence of a "globule" of extruded spores at the mouth of the pycnidium, and not upon the presence of a "beak" as understood by Saccardo.

possible to examine this type specimen, which is in Hungary, the description, meagre as it is, fits in well with the fungus now under consideration; these fungi are therefore probably identical. It is thought advisable, however, to amplify Hollós' description, and the fungus will be named *Diplodina Lycopersici* (Cooke) Hollós emend. Brooks and Searle*.

Diplodina Lycopersici (Cooke) Hollós emend. Brooks and Searle.

Pycnidia scattered to aggregate, subcutaneous but subsequently erumpent, glabrous, brown to brownish-black, subglobose, slightly papillate, ostiolate (usually one sometimes 2–3 pores), 100–270 μ in diameter; pycnospores issuing in coils through the ostiolum, forming a dirty white to flesh-coloured exudate; hyaline; continuous to 1-septate (the percentage of septate spores is very variable), slightly constricted at the septum, 2-guttulate, or devoid of guttules, 4·5–17 μ × 2·5–5 μ (average 9·4 μ × 4 μ), sub-cylindrical, produced singly as unbranched conidiophores. No definite stroma; no perithecial stage observed. Parasitic on green and ripe fruits of tomatoes, causing a soft rot, also on the stems, especially just above soil level.

It is considered that the fungus, isolated both from tomato stems and tomato fruits, which was the subject of investigation by one of us(2) some years ago was identical with this. It was then shown that the so-called tomato "canker" fungus was capable of causing a rot of the fruit, and that the same fungus isolated from rotting fruits was able to induce a "canker" of the stem†.

Series 3.

Pycnidial form accompanied by *Alternaria* spores on the same mycelium.

Form C.

It is proposed to name the fungus obtained from tomato fruits *Phoma alternariaceum* Brooks and Searle.

Phoma alternariaceum Brooks and Searle.

Pycnidia aggregate, glabrous, brown to black, subglobose, slightly papillate, ostiolate (usually one, sometimes two pores),

* Since this paper was written, a description of tomato "canker" as it occurs in Germany has appeared (Klebahn, N., "Der Pilz der Tomatenstengelkrankheit und seine Schlauchfruchtsform," Zeitschrift für Pflanzenkrankheiten, XXXI, 1921, p. 1) Klebahn also refers the fungus to *Diplodina Lycopersici* Hollós. He has, moreover, found the perithecial stage, which he names *Didymella Lycopersici*.

† During the summer of 1921, the stem canker form of this disease was received both from this country (through Mr A. D. Cotton) and from Holland (through Dr C. Schoevers). In each the fungus was identical with *Diplodina Lycopersici* (Cooke) Hollós.

100–250 μ in diameter; pycnospores issuing in coils, through the ostiolum, forming a flesh-coloured exudate; hyaline, continuous, sometimes faintly bi-guttulate, 3–7·6 μ × 2–3·5 μ (average 6 μ × 3 μ), ovate with a tendency to pointed ends, produced singly on unbranched conidiophores. Pycnidia accompanied by aerial mycelium bearing spores of the *Alternaria* type produced in chains. *Alternaria* spores 40–80 μ × 12–18 μ, multiseptate, dark brown. On green and ripe tomato fruits, causing a rot.

The following diagnosis in Latin has been kindly drawn up by Mr Gepp and Mr Ramsbottom of the British Museum:

Phoma alternariaceum Brooks and Searle.

Pycnidiis aggregatis, glabris, brunneis atrisve, subglobosis, papillulatis, ostiolatis, poro (interdum poris duobus) pertusis, 100–250 diam.; sporulis poro erumpentibus et cirrum roseolum protrudentibus, hyalinis, continuis, interdum obscure bi-guttulatis, 3–7·5 μ × 2–3·5 μ (plerumque 6 μ × 3 μ), ovatis utrinque subacutis, e sporophoris simplicibus singulariter orientibus.

Pycnidiis mycelio aerio sporas typi *Alternariae* catenatis gerenti se sociantibus. Sporis *Alternariae* 40–80 μ × 12–18 μ, multiseptatis, atrobrunneis.

In Lycopersici fructibus viridibus maturisque, et pulpam putrefaciente.

In consulting the literature on *Alternaria* and *Phoma*, only two species of the latter have been found, in the life-cycle of which an *Alternaria* form has been described. These are two saprophytic species, *Phoma Richardiae* and *Phoma fictilis* mentioned by Miss Westerdijk and Miss van Luijk(16) as having been grown by them. Many years ago, Kohl(8) in trying to clear up the obscurities concerning the spore forms of *Pleospora herbarum*, found a fungus, the pycnospores of which gave *Alternaria* spores as well as pycnidia in pure culture, but this species was not named, nor was it genetically connected with the *Pleospora*. It is interesting to note in this connection that Brefeld(1) found *Alternaria* stages, but not pycnidia, in the life-history of *Pleospora vulgaris* and *Pleospora infectoria*, while in *Pleospora herbarum* the accessory spore form was *Macrosporium commune*.

Some years ago Massee(10) described a disease of tomato fruits caused by *Macrosporium tomato* and stated that pycnidia forming hyaline conidia accompanied the multiseptate spores, although no proof was brought forward that the two spore forms were genetically connected. In our investigations, species of *Macrosporium* have frequently been seen on diseased tomato fruits but upon isolation have always proved to be non-pathogenic. It seems likely that Massee's account of a tomato fruit

disease was based upon a mixture of forms. In America it has been shown by Rosenbaum and Sando* that *Macrosporium tomato* Cke. may be the cause of a disease of uninjured tomato fruits.

Series 4.

This includes the forms *K*, *K* 2, and *S* with the authenticated culture of *Colletotrichum phomoides* (Sacc.) Chest. (Form *D*).

As has been noted by Shear and Wood (15 p. 64) in dealing with the ascomycetous genus *Glomerella*, the conidial stage (*Gloeosporium* or *Colletotrichum*) shows great variability in its mode of formation and in morphological characters. In some cultures the conidia are borne on scattered conidiophores and in others large compact acervuli occur. Later these authors point out that setae are also a variable factor, being entirely absent in some cultures and present in others.

This variability was also noted by us in the four forms studied, and again, as in Series No. 2, makes the taxonomic arrangement of the forms very difficult.

In comparing the forms *K*, *K* 2, and *S* with the authenticated culture (*D*) of *Colletotrichum phomoides* (Sacc.) Chest.(3) it was found that form *S* was identical with the latter, except that setae were not always produced in artificial media, although when transferred to tomato fruits setae were abundantly formed. The acervuli varied from 180–360 μ in diameter and the conidia were borne at the apex of short branched conidiophores. The conidia were usually cylindrical with rounded or slightly pointed ends, very regular in shape and size, and always unicellular. The cell contents were very granular.

The great majority of conidia were uniform in size at 21 $\mu \times 4\,\mu$, though conidia were seen varying between 14 μ to 24 $\mu \times 3\,\mu$ to 4·5 μ. This form can therefore be undoubtedly diagnosed as *Colletotrichum phomoides* (Sacc.) Chest., and is, we believe, its first recorded appearance in England.

The forms *K* and *K* 2 were identical one with the other but both slightly differed from forms *D* and *S*, since, on artificial media large compact black acervuli were very seldom formed, the conidia being borne on cushion-like loose aggregations of conidiophores. Spore-formation seemed to be much more profuse than in the other forms, as the spores were produced in such abundance that the whole surface of the fruit was covered with pink masses of conidia almost coalescing one with another. Some conidia were very slightly curved; they were all non-septate, very uniform in size and vacuolate. Setae were not observed. The size of the conidia in *K* varied from 19 μ to

* Rosenbaum, J. and Sando, C. E. Correlation between size of fruit and its relation to infection with *Macrosporium tomato*. Amer. Journ. Bot., 1920.

30 μ × 5 μ to 8 μ, and of *K* 2 from 14 μ to 30 μ × 5 μ to 7·5 μ, 20 measurements being taken in each case.

Mention has already been made that form *K* 2 produced typical acervuli on one artificial medium, so that it seems probable that these two forms can also be provisionally included under the species *Colletotrichum phomoides.*

Series 5.

Series 5 consists only of form *N* which was a typical species of *Fusarium.*

On Dox's agar, the colour of the spores in mass was orange salmon. The spores were crescent-shaped with pointed ends, 2–4 times septate, 3–4 μ × 24–36 μ. When fully mature, one cell of the spore was often thick-walled and apparently functioned as a resting spore. Two species of *Fusarium* are recorded by Saccardo (13) as occurring on tomato fruits, *F. aurantiacum* Link, and *F. oxysporum* Schlecht. var. *Lycopersici* Sacc., but in the absence of comparative cultures, it is impossible to identify the species. It is probable that many species of this genus would cause a rot of tomato fruits if inserted in them through wounds, and in fact a pure culture of *Fusarium caeruleum* obtained from potatoes, produced a soft rot.

GENERAL CONSIDERATIONS.

It would appear from this review of a number of forms of fungi parasitic on the tomato fruit that the whole question of the taxonomy of difficult genera like *Phoma, Ascochyta, Diplodina, Colletotrichum* and *Gloeosporium* is one requiring considerable attention from systematists. At present the species in these genera are almost numberless and seem to be added to on very slender grounds and without much regard to the true relationships between them, which can only be determined by careful cultural work. To add new species indiscriminately on the grounds of host relationship, or on a variation in some small morphological detail, which if studied in cultural form will often turn out to be within the "experimental error" or ordinary range of variability, is much to be deplored and adds largely to the difficulties of later investigators. In the forms here investigated, this variability was found to be very marked, especially in such morphological details as septation of spores, a character often looked upon as specific and one in which some systematists beg the question by adding such phrases as "becoming septate later" or "the septation is tardy in appearing."

SUMMARY.

Various rots of tomato fruits and certain diseases of the stems of tomato plants have been investigated. These fruit rots commonly occur both on imported and upon home-grown fruit, and are caused by several different fungi about the identity of which there has been much uncertainty. The fungi isolated from rotten tomatoes have been compared with authentic cultures of certain presumably identical or closely related fungi from the United States. One of the rots is caused by *Phoma destructiva*, the British form of which is identical with that from America. Another of these rots is produced by a fungus which has hitherto passed in this country under the name of *Mycosphaerella citrullina*, but which is certainly not identical with the American fungus of that name. The British fungus which has hitherto been mistaken for this and which causes tomato stem "canker" as well as a fruit rot, appears to be identical with *Diplodina Lycopersici* Hollós which name also replaces *Phoma Lycopersici* Cooke. It has been considered advisable to amplify Hollós' description and the fungus is therefore named *Diplodina Lycopersici* (Cooke) Hollós, emend. Brooks and Searle. Another pycnidial fungus, found only once as the cause of a tomato rot, is associated with an *Alternaria* stage, and the name proposed for this fungus is *Phoma alternariaceum* Brooks and Searle. Finally, various strains of *Gloeosporium* and *Colletotrichum* parasitic on tomatoes have been isolated. One of these fungi is identical with the American *Colletotrichum phomoides* (Sacc.) Chester, and probably all of these forms are thus best grouped.

The desirability of undertaking cultural sudies of fungi belonging to such genera as *Phoma*, *Diplodina*, and *Colletotrichum* as an aid in the diagnosis of species, is emphasised.

POSTSCRIPT.

Since this paper went to press, Petrak, in a note "Über die Schwarzfäule der Tomaten" (Annales Mycologici, 1921, p. 17), describes a fungus occurring on the leaves, stems, and fruits of the tomato, which he considers identical with Plowright's *Phoma destructiva*, but which he now names *Diplodina destructiva* (Plowr.) Petrak, because of the uni-septate character of the pycnospores formed on the leaves and stems although the spores are almost entirely non-septate in pycnidia on diseased fruits. Petrak's survey of the literature on this and allied tomato diseases is very incomplete, and, in the absence of inoculation and cultural experiments, it is by no means certain that he was dealing with one fungus only. As pointed out in our paper, it is doubtful whether a sharp line can be drawn between *Phoma destructiva* (Plowr.) C. O. Jamieson, and *Diplodina Lycopersici* (Cooke) Hollós, but in view of the above considerations and of the constantly non-septate character of the spores obtained both by Miss Jamieson and ourselves from certain forms of fruit disease, even under cultural conditions, it seems desirable to retain both these names. As stated previously, the generic distinctions between *Phoma* and *Diplodina* seem to have broken down in this group of fungi, and we appear to be dealing here with a series of closely-related forms, rather than with clearly-defined species.

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HOMOTHALLISM AND THE PRODUCTION OF FRUIT-BODIES BY MONOSPOROUS MYCELIA IN THE GENUS COPRINUS.

With Plates VI and VII.

By Miss Irene Mounce, M.A. (British Columbia).

I. Introduction.

In a publication entitled "Recherches sur le cycle évolutif et la sexualité chez les Basidiomycètes" Mlle M. Bensaude* records the results of certain experiments and cytological observations which appear to show that *Coprinus fimetarius*—one of the Basidiomycetes—resembles certain Mucorini investigated by Blakeslee in that it is *heterothallic*.

In making cultures of *Coprinus fimetarius* in Van Tieghem cells, Mlle Bensaude obtained four mycelia, each of which had originated from a single spore. These four monosporous mycelia were transferred to tubes, but only two of them survived this change of conditions and continued to grow. The two surviving monosporous mycelia, α and β, were sub-cultured; but during eight months they remained in the *primary* condition, *i.e.* none of them developed clamp-connections or paired nuclei, and they all proved quite *sterile*, for none of them produced any fruit-bodies. On the other hand, the behaviour of a mycelium of polysporous origin was quite different. Mlle Bensaude obtained polysporous mycelia by mixing pieces of the mycelia of mycelium α and mycelium β. She found that, as a result of hyphal fusions taking place between α and β, a mycelium was produced which was definitely secondary in nature, for its nuclei were paired and divided conjugately, the division of each dicaryon was accompanied by the formation of a septum with a clamp-connection, and the mycelium as a whole was fertile, as was shown by the production of fruit-bodies.

Mlle Bensaude's criteria for determining heterothallism in her fungus were: (1) the isolated condition of the nuclei and the absence of clamp-connections in monosporous mycelia, (2) the formation of dicaryons and clamp-connections when two different mycelia, α and β, were brought together so that they might anastomose with one another, and (3) the sterility of

* Mathilde Bensaude, Recherches sur le cycle évolutif et la sexualité chez les Basidiomycètes, Nemours, 1918, pp. 1–156, nine plates.

monosporous mycelia and the fertility of the compound bisporous mycelia.

Hans Kniep who has also investigated the sexuality of the Hymenomycetes, accepts the first two of Mlle Bensaude's criteria for heterothallism but not the third. He has made the remarkable discovery that the fruiting of a mycelium of a heterothallic Hymenomycete, *e.g. Schizophyllum commune*, does not necessarily depend upon the nuclei in the mycelium becoming paired, so that a haploid mycelium derived from a single spore may produce fruit-bodies resembling in external appearance and in the production of numerous ripe spores the fruit-bodies of the same species produced on a diploid mycelium derived from the fusion of two monosporous mycelia of opposite sex*. Hence the mere formation of fruit-bodies by a monosporous mycelium is no clear indication that the fungus is homothallic; for, notwithstanding its fruit-bodies, it may be heterothallic. According to Kniep, in a heterothallic species, the difference between a haploid fruit-body produced by a monosporous mycelium and a diploid fruit-body produced by a compound mycelium which has originated from two mycelia of opposite sex lies in this: that each basidium of a haploid fruit-body has only one nucleus in it when it is cut off from its parent subhymenial cell, whereas each basidium of a diploid fruit-body, when cut off, always contains two nuclei. In the haploid basidium, the single nucleus divides twice; whereas, in the diploid basidium, the two original nuclei first fuse together and the fusion nucleus divides twice. Thus in the haploid basidium there is no nuclear fusion, whereas in the diploid basidium such a fusion always takes place. According to Kniep, in a heterothallic species all the spores of a haploid fruit-body are of the same sex, whereas those of a diploid fruit-body are divided into groups which are sexually different.

Kniep† and Mlle Bensaude‡, working independently, have both found that the formation of clamp-connections in the mycelium of any Hymenomycete is associated with the conjugate division of the nuclei. Hence the existence of clamp-connections in a mycelium is an outward and visible sign of the fact that the nuclei in the mycelium exist not as isolated units but in the paired state, *i.e.* as dicaryons. If, therefore, in any species of Hymenomycete, one finds clamp-connections always forming in individual mycelia of monosporous origin, one is justified in concluding that the species is homothallic; but if clamp-

* Hans Kniep, Über morphologische und physiologische Geschlechtsdifferenzierung. Verhandl. der Physikal.-med. Gesellschaft zu Wurzburg, 1919, p. 10.

† Hans Kniep, Beiträge zur Kenntnis der Hymenomyceten, III, IV and V. Zeitschr. f. Botanik, VII, 1915, VIII, 1916, and IX, 1917.

‡ Mlle Bensaude, *loc. cit.*

connections are not found in such monosporous mycelia but only in compound mycelia formed by the union of two mycelia presumably of opposite sex, then one is justified in concluding that the species is heterothallic.

Kniep, when working with *Schizophyllum commune* which is heterothallic, discovered that when a heterothallic species produces a fruit-body from a mycelium of monosporous origin, not only is the fruit-body haploid but all the spores which it produces are of the same sex. Evidence of this fact was obtained by sowing the spores of a haploid fruit-body in large numbers together in the same culture medium and by observing that clamp-connections were never formed in the compound mycelium which resulted. The nuclei in the compound mycelium just described, therefore, never arranged themselves in the form of dicaryons. Assuming these facts to be true, we are provided with a second criterion for determining whether a species which produces clamp-connections is homothallic or heterothallic. If clamp-connections are found in a compound mycelium arising from the sowing of numerous spores obtained from a fruit-body of monosporous origin, then we are justified in supposing that the species is homothallic; but, if no clamp-connections are formed, then the species is heterothallic.

Kniep*, using the clamp-connection criteria, states that he has proved experimentally that the following species of Hymenomycetes are heterothallic:

Polyporus versicolor.	*Mycena calopus.*
Typhula erythropus.	*M. parabolica.*
Peniophora corticalis.	*Clitocybe infundibuliformis.*
Stereum purpureum.	*Hypholoma fasciculare.*
Schizophyllum commune.	*H. sublateritium.*
Marasmius alliaceus.	*H. capnoides.*
Armillaria mucida.	*H. Candolleanum.*
Collybia butyracea.	*H. hydrophilum.*
C. asema.	*Pholiota mutabilis.*
C. tuberosa.	*P. praecox.*
C. velutipes.	*Coprinus stercorarius.*

He also states that homothallic Hymenomycetes exist and cites as examples:

Hypochnus terrestris.	*Stereum hirsutum.*
Typhula sp.?	

In view of the importance of Mlle Bensaude's conclusion that certain Basidiomycetes are heterothallic, it seemed desirable, if possible, to repeat her experiments with a number of different species. At the suggestion of Professor Buller, therefore, I have

* Hans Kniep, Über morphologische und physiologische Geschlechtsdifferenzierung, *loc. cit.* pp. 12 and 13. This list is given in a foot-note without further details.

made a series of experiments on the fruiting powers of monosporous and polysporous mycelia of a number of species of Coprinus occurring on horse dung at Winnipeg. These coprophilous fungi yield an abundance of fruit-bodies spontaneously on unsterilised horse dung, can be readily grown in pure culture from spores, complete their life-histories in a very few weeks, and have black or dark brown spores which stand out conspicuously in agar plates when examined under the low power of the microscope. They were thus well suited to serve as material for my investigations. Kniep's papers became available six months after the work was begun.

Until the investigations here described were almost completed, I thought, like Mlle Bensaude, that if a monosporous mycelium of any species could produce fruit-bodies, evidence was thereby obtained which proved that the species is homothallic and not heterothallic. However, as soon as Kniep's 1919 paper came into my hands, I perceived that the criterion of fruit-body production is insufficient for determining the question of homothallism and heterothallism. I have not made any cytological studies either of mycelia or fruit-bodies. For determining that any species of Coprinus is homothallic and not heterothallic, I have relied upon two criteria only: (1) the occurrence of clamp-connections upon mycelia of monosporous origin, and (2) the occurrence of clamp-connections or compound mycelia arising from spores all of which have been derived from a single fruit-body produced from a mycelium of monosporous origin. The value of these two criteria has already been discussed.

Monosporous mycelia have been successfully isolated and cultivated for the following nine species:

Coprinus sterquilinus Fr.
C. lagopus Fr.
C. stercorarius Fr.
C. niveus Fr.
C. ephemerus Fr.
C. curtus Kalchb.
C. stellatus Buller.
C. cordisporus Gibbs.
C. comatus Fr.

The name *Coprinus stellatus* at present is a *nomen nudum*. The variety of *Coprinus ephemerus* made use of was purplish in colour. This form occurs both in England and Canada. Altogether, for the nine species, fifty-six monosporous mycelia were successfully transferred to culture media. Of these fifty-six mycelia all except three (one of the *C. niveus* cultures and the two *C. comatus* cultures) produced fruit-body rudiments; but, as we shall see, in many of the cultures, the rudiments never developed into mature fruit-bodies shedding spores.

II. Methods.

Horse-dung balls were collected from stables and from the streets of Winnipeg and were placed in a large glass chamber set on a table in the laboratory. In the course of a few weeks, fruit-bodies of the nine species of Coprinus named above, with the exception of *Coprinus comatus*, appeared on the dung balls. Spore-deposits were collected on sterilised filter paper by placing this beneath pilei which were shedding spores. When a spore-deposit had been obtained, the filter paper bearing it was labelled and set in a sterilised glass container. It was then ready for use at any time.

Experiments were made with beef-peptone agar, beef-peptone gelatine, malt gelatine, and potato agar; but the medium used for all the later experiments was a horse-dung decoction solidified with 1·3–2 per cent. agar. This culture medium was made as follows. Approximately 400 grams of fresh horse-dung were put in a beaker with 1000 cc. of tap-water and the whole was placed in a steam steriliser at a temperature of 100° C. for 30 minutes. To the decoction so obtained was then added 1·3–2 per cent. of melted agar. The horse-dung agar was then filtered through cotton-wool, and, thereafter, 10 cc. of it was poured into each of a series of test-tubes. These tubes, which were plugged with cotton-wool, were then autoclaved at a pressure of seven pounds for half an hour or longer. The medium was not titrated.

To isolate the monosporous mycelia, the poured plate or Petri dish method was employed. Tubes of horse-dung agar which had been melted and cooled to a temperature of 42°–45° C., were inoculated with a few spores introduced by means of a sterilised platinum needle from a spore-deposit. The agar was then poured into sterilised Petri dishes. The dishes were placed in a cupboard and kept at room temperature, *i.e.* at about 20°–22° C. After from two to five days, varying with the species, minute mycelial masses could be seen with the naked eye upon the agar; and, with the low power of the microscope, it was found that some of these had developed from small clumps of spores and others from single spores (Pl. VI, Figs. 1, 2, 5, 10). The spores could be very readily distinguished owing to their blackness. When a mycelium was found to have developed from a single spore which was far distant from any other spore or mycelium, it was removed from the Petri dish with a sterilised platinum needle and transferred to a dung-agar slant. Usually within two to four days the mycelium had extended itself considerably over the agar surface. It was then finally transferred, along with the agar which it covered, to a

wide glass tube (length 4 inches, breadth 1·25 inches) which, after having been half filled with fresh horse-dung and plugged with cotton-wool, had been sterilised in flowing steam for 45 minutes on three successive days. This tube was set in a cupboard or on a table away from direct sunlight and kept at room temperature.

Whilst isolating monosporous mycelia of any species, a polysporous mycelium which had originated from several germinating spores of a spore clump, was also isolated; and it was transferred first to a slant and then to a wide tube in the same manner as, and at the same time as, the monosporous mycelia. Thus controls were provided.

III. *Coprinus sterquilinus.*

The first experiments were made with *Coprinus sterquilinus*, a species which has very large black spores, a rapidly-growing dense white mycelium, and a large fruit-body*. Potato agar was employed for the plates and slants in the earlier cultures, and dung agar in the later ones. The methods of cultivation were identical with those described above except in the last few cultures where I transferred the monosporous mycelia directly from the Petri dish to the tubes of sterilised dung. Altogether twenty-five monosporous mycelia were isolated, but four of them failed to grow after being transferred. Each of the twenty-one mycelia which survived transference, grew well and completely covered the horse-dung balls with a white felt-work. A considerable number of rudimentary fruit-bodies soon appeared on the mycelium covering the dung balls; and, after 24–31 days from the time the spores were first sown, some of the fruit-bodies elongated their stipes, expanded their pilei, and shed great numbers of spores. Thus each of the twenty-one monosporous mycelia fruited in a perfectly normal manner.

Included in the twenty-one monosporous cultures was a series which may be described as follows. A wild fruit-body came up on horse-dung taken from a stable, and it shed spores which were collected as a spore-deposit. Some of the spores were plated out on agar and thus a monosporous mycelium was obtained. A month after being transferred to sterilised horse-dung in the usual way, the mycelium fruited. From this second fruit-body, a second monosporous mycelium was obtained which at the end of a second month also fruited; and from the third fruit-body a third monosporous mycelium was obtained which

* For a description of the fruit-body with illustrations *vide* A. H. R. Buller, Die Erzeugung und Befreiung der Sporen bei *Coprinus sterquilinus*, Pfeffer's Festschrift, identical with Jahrb. f. wiss. Bot. LVI, 1915, pp. 299–329, Taf. II and III.

at the end of the third month also fruited; and so on for five successive generations. If we let S = a single spore, MM = a monosporous mycelium, and F = a fruit-body, then the sequence just described may be set forth as follows:

$$F) \longrightarrow (S \rightarrow MM \rightarrow F) \longrightarrow (S \rightarrow MM \rightarrow F) \longrightarrow$$
$$(S \rightarrow MM \rightarrow F) \longrightarrow (S \rightarrow MM \rightarrow F) \longrightarrow (S \rightarrow MM \rightarrow F).$$

Thus fruit-bodies of *Coprinus sterquilinus* were obtained in monosporous cultures for five successive generations*. The first fruit-body of the fifth generation is shown in Plate VII, Fig. 1.

Experiments with twenty-one monosporous cultures of *Coprinus sterquilinus* has taught me that this fungus fruits from mycelia of monosporous origin with remarkable certainty and perfection. In a monosporous culture of this species one can rely upon seeing fruit-body rudiments appear at the surface of the dung after about a fortnight from the sowing of the spores, and one can also rely upon obtaining mature fruit-bodies, producing vast numbers of spores, from some of the same rudiments at the end of about a month from the time of the sowing of the spores. All the monosporous cultures of *Coprinus sterquilinus*, therefore, behave in exactly the same manner so far as fruiting is concerned.

We may now ask: is *Coprinus sterquilinus* homothallic or heterothallic? Accepting Kniep's view that the production of fruit-bodies on a monosporous mycelium is no proof that the species is homothallic, it is therefore necessary for us to answer our question by the criterion of clamp-connections. I found that all the mycelia of monosporous origin which I studied after the first few days of their development, even those of the fifth successive generation, exhibited clamp-connections with great regularity on all the stout hyphae radiating from the centres of growth (Plate VI, Figs. 3 and 4). It seems to me, therefore, that there can be no doubt that *Coprinus sterquilinus* is a homothallic species.

Polysporous mycelia arising from the union of the mycelia, coming from several spores sown in a clump, were isolated from agar plates and grown side by side with monosporous mycelia as controls. No difference between the polysporous mycelia and the monosporous ones could be observed as regards rapidity of appearance of mycelial growth, presence of clamp-connections, rapidity of fruiting, or in the perfection of the fruit-bodies produced. The polysporous cultures fruited sometimes a day or

* Since this was written, fruit-bodies have been obtained from a sixth successive monosporous culture.

two ahead of the first monosporous cultures and sometimes a day or two later. There was nothing to show that a polysporous culture has any more vigour than a monosporous culture.

Although it appears that *Coprinus sterquilinus* is undoubtedly homothallic and that it is perfectly vigorous when its nuclei become paired as a result presumably of hyphal fusions taking place between branches of the same mycelium; yet, under natural conditions, crossing is by no means excluded and probably often takes place. When several spores germinate together, as they must often do in horse-dung in fields, the mycelia doubtless soon anastomose. Thus the condition is provided, even in a homothallic species, for the first dicaryon to arise by a nucleus of one mycelium moving across a bridging hypha to another mycelium and thus pairing with one of the latter's nuclei. An analogy is provided by certain hermaphrodite Flowering Plants in which either self-pollination or cross-pollination may take place.

IV. *Coprinus lagopus.*

Coprinus lagopus, which was the second species studied, comes up very commonly on unsterilised horse-dung cultures in both Europe and North America. The fruit-bodies obtained at Winnipeg fit the description of *C. lagopus* as given in Lange's monograph on the genus Coprinus*, and they also correspond in detail with the illustrations of *C. lagopus* as given by Brefeld†.

Ten monosporous mycelia and one bisporous mycelium of *Coprinus lagopus* were isolated from dung-agar plates, transferred individually to dung-agar slants, and finally transferred to wide tubes containing sterilised horse-dung. Within fourteen days from the time the spores were plated out from the spore-deposit, the mycelia on the eleven agar slants all showed rudimentary fruit-bodies; and, subsequently, in nine out of the ten monosporous cultures as well as in the bisporous culture, some of the fruit-bodies expanded. The bisporous mycelium produced a fruit-body one day after the monosporous ones, but otherwise behaved precisely as they did. The monosporous dung cultures varied somewhat in the length of time they took to develop. Transferring the mycelium to the dung seemed to check the growth of some of them temporarily. Seven of them produced rudimentary fruit-bodies seven days after transference to dung, one nine days after, one ten days after, and the last sixteen days after transference. The bisporous mycelium de-

* Jacob E. Lange, Studies in the Agarics of Denmark, Dansk Botanisk Arkiv, Bd. II, Copenhagen, 1915, p. 41.

† O. Brefeld, Untersuchungen, Leipzig, Heft III, 1877, Taf. VI, fig. 1, *a–g*.

veloped fruit-bodies one day before the first monosporous mycelium. Although all the eleven dung cultures produced rudimentary fruit-bodies, in only six of them did the rudiments continue their development to maturity. This, however, appeared to be due to the conditions of nutrition, aeration, transpiration, etc.; for, when transfers were made to large masses of sterilised dung contained in crystallising dishes, fruit-bodies were produced which elongated their stipes, expanded their pilei, and shed spores in the normal manner (Plate VII, Fig. 2).

Later, an eleventh monosporous mycelium was removed from a dung-agar plate and placed directly in a large crystallising dish of horse-dung which had been sterilised by heating on three successive days. This culture showed very little surface mycelium but eventually produced several large normal fruit-bodies.

All the fruit-bodies produced in the monosporous and the bisporous agar-tube and dung-tube cultures were imperfect, *i.e.* their pilei produced no ripe spores and, at maturity, were, therefore, white or pale yellow instead of being grey. However, when monosporous mycelia were transferred from the tubes to sterilised horse-dung contained in large crystallising dishes, they produced many perfect spore-bearing fruit-bodies, as well as some which produced many spores which never ripened, very few ripe spores, or no spores at all. This imperfection of certain of the fruit-bodies in each large pure culture, in respect to spore-production, was observed not only in all the monosporous cultures, but also in all the polysporous cultures. Altogether seventeen cultures exhibited imperfect spore-production and, of these, ten were monosporous in origin and seven polysporous. Since the fruit-bodies of both monosporous and polysporous pure cultures behave in the same manner as regards imperfection of spore-production, this phenomenon cannot be due to the haploid or diploid condition of the mycelium but must be due to some other cause, such as the over-production of fruit-bodies of large size or to the absence from the nutrient medium of certain chemical compounds which in unsterilised dung are ordinarily produced by associating and competing organisms.

A wild fruit-body of *Coprinus lagopus* came up on horse-dung taken from a stable, and it shed spores which were collected as a spore-deposit. Some of the spores were plated out on agar and thus a monosporous mycelium was obtained. This mycelium was transferred to sterilised horse-dung in a large crystallising dish. Here it fruited nineteen days after the spore from which it originated had been sown. From this second fruit-body a second monosporous mycelium was obtained which also fruited.

Using the same symbols as before, the sequence may be expressed as follows:

$$F) \longrightarrow (S \rightarrow MM \rightarrow F) \longrightarrow (S \rightarrow MM \rightarrow F).$$

Thus fruit-bodies of *Coprinus lagopus* were obtained in monosporous cultures for two successive generations.

Judged by the criterion of the appearance of clamp-connections in a mycelium of monosporous origin, *Coprinus lagopus* is homothallic, for clamp-connections developed: (1) on each of several mycelia of monosporous origin derived from the spores of a wild fruit-body (Plate VI, Figs. 6 and 7), and (2) on each of three mycelia of monosporous origin derived from spores produced by a fruit-body of monosporous origin. This conclusion is confirmed by the fact that clamp-connections also appeared on (3) a compound mycelium of polysporous origin derived from many spores produced by a fruit-body of monosporous origin (Plate VI, Fig. 8). Were *Coprinus lagopus* heterothallic, instead of being homothallic, no clamp-connections should have developed on any of the three kinds of mycelia just described.

Judging by Mlle Bensaude's illustrations and description of *Coprinus fimetarius*, it seems not improbable that this species is identical with the one which, upon the advice of Professor Buller, I call *C. lagopus*. A *Coprinus fimetarius* distinct from *C. lagopus* and coming up on unsterilised horse-dung has not been found at Winnipeg, and my *Coprinus lagopus*, as Professor Buller has proved by comparative cultures, is the same as the *C. lagopus* which so commonly comes up on unsterilised horse-dung in laboratory cultures in England. Certainly Mlle Bensaude's *C. fimetarius* and my *C. lagopus* have fruit-bodies which appear to me to be identical in external appearance. Even if, after all, Mlle Bensaude's species should prove to be different from my *C. lagopus*, it will be necessary to admit that the two species are very closely related; and it is, therefore, not a little remarkable that they should behave so differently as regards sex, Mlle Bensaude's species being heterothallic and my own homothallic.

V. *Coprinus stercorarius.*

The third species investigated was the well-known *Coprinus stercorarius* the life-history of which was described by Brefeld*, and which is remarkable in that it produces small black sclerotia the size of dried peas. After plating out some spores from a wild fruit-body, two monosporous mycelia were obtained, which, after being transferred to dung-ball tubes in the usual way,

* O. Brefeld, Untersuchungen, Leipzig, Heft III, 1877, pp. 13–67.

continued growing. Their hyphae scarcely showed themselves on the surface of the dung. However, after twelve days had passed, sclerotia began to develop on the dung in both tubes. These sclerotia which were at first white, grew rapidly in size, excreted large water drops, and then turned black on their exterior, except where they happened to press against the glass. Two ripe sclerotia were removed and placed on wet sterilised sand under a bell-jar; and there, after a few days, they developed normal fruit-bodies which shed vast numbers of spores. Thus for *Coprinus stercorarius* two mycelia of monosporous origin, like similar mycelia of *C. sterquilinus* and *C. lagopus*, fruited in a perfectly normal manner.

A wild fruit-body of *Coprinus stercorarius* came up from a sclerotium which developed spontaneously on horse-dung in the laboratory, and it shed spores which were collected as a spore-deposit. Some of the spores were plated out on agar and thus a monosporous mycelium was obtained. This mycelium, after being transferred to a horse-dung tube, produced a sclerotium, and the sclerotium produced a second fruit-body. From this second fruit-body four monosporous mycelia were obtained. Of these, up to the present, one has produced sclerotia only, one sclerotia and several fruit-bodies directly from the dung, and two fruit-bodies directly from the dung but no sclerotia. Using the same symbols as before, the sequence for a single line may be expressed as follows:

$$F) \longrightarrow (S \rightarrow MM \rightarrow F) \longrightarrow (S \rightarrow MM \rightarrow F).$$

Thus fruit-bodies of *Coprinus stercorarius* have been obtained in monosporous cultures for two successive generations.

In *Coprinus stercorarius*, just as for *C. lagopus*, clamp-connections were found on the following kinds of mycelia: (1) several mycelia of monosporous origin, the spores having been derived from a wild fruit-body, (2) a mycelium of monosporous origin derived from a spore produced by a fruit-body of monosporous origin, and (3) a compound mycelium of polysporous origin derived from spores produced by a fruit-body of monosporous origin (Plate VI, Fig. 9). We may conclude, therefore, just as we did for *C. lagopus*, that *Coprinus stercorarius* is homothallic.

Kniep states, without as yet giving the details of his evidence, that *Coprinus stercorarius* is heterothallic*. My observations which have clearly shown that clamp-connections in *C. stercorarius* appear in monosporous mycelia, do not support Kniep's statement. Judged by the clamp-connection tests, *C. stercorarius* is certainly homothallic.

* Hans Kniep, Über morphologische und physiologische Geschlechtsdifferenzierung, *loc. cit.* p. 13, foot-note.

VI. *Coprinus niveus.*

From the spores of a wild fruit-body five monosporous mycelia were obtained by plating, and they were transferred to dung-tubes in the usual way. Of these five mycelia, two yielded normal fruit-bodies which expanded and shed spores, two yielded rudimentary fruit-bodies which never expanded or shed spores, while one did not produce any rudiments at all. It therefore seems that, in *Coprinus niveus*, some monosporous mycelia fruit very much more readily than others and that some of the mycelia may not be able to fruit at all. It was found that compound mycelia of polysporous origin, the spores having been derived from a wild fruit-body, fruited much more vigorously and several days sooner than any of the monosporous mycelia. Thus *Coprinus niveus*, in contrast with *C. sterquilinus*, is very uncertain in respect to the fruiting of its monosporous mycelia.

Fruit-bodies of *Coprinus niveus* were obtained in monosporous cultures for two successive generations. This result, using the symbols already employed, may be expressed as follows:

$$F) \longrightarrow (S \rightarrow MM \rightarrow F) \longrightarrow (S \rightarrow MM \rightarrow F).$$

In *Coprinus niveus*, just as in *C. lagopus* and *C. stercorarius*, clamp-connections were found in the following kinds of mycelia: (1) several mycelia of monosporous origin, the spores having been derived from a wild fruit-body, (2) two mycelia of monosporous origin derived from two spores produced by a fruit-body of monosporous origin, and (3) a compound mycelium of polysporous origin derived from many spores produced by a fruit-body of monosporous origin (Plate VI, Fig. 11). Hence we may conclude, just as we did for *C. lagopus* and *C. stercorarius*, that *Coprinus niveus* is homothallic and not heterothallic.

Since *Coprinus niveus* is homothallic, it is remarkable that its monosporous mycelia are so very uneven in their power of producing fruit-bodies. It seemed possible that two monosporous mycelia, if allowed to combine in the same culture vessel, might fruit more vigorously from the compound mycelium thus produced than either would fruit if kept isolated by itself. Accordingly sub-cultures were made from three of the five first-made monosporous cultures. Let us call these cultures *A*, *B* and *C*. *A* had produced normal fruit-bodies, *B* only fruit-body rudiments, and *C* no rudiments at all. From these cultures six dung-tube sub-cultures were made as follows:

(1) *A* by itself,	(4) $A + B$,
(2) *B* „	(5) $A + C$,
(3) *C* „	(6) $B + C$,

and all the cultures were kept under the same external conditions.

The result of the experiment was truly remarkable, for the three mixed cultures all fruited vigorously and their fruit-bodies shed spores 24–28 days after the sub-cultures had been made; whilst, at the end of this time, the unmixed cultures showed not even a single fruit-body rudiment. The culture (1) *A* by itself, showed its first rudiments after about 29 days, but the fruit-body did not expand until the 33rd day. The other unmixed cultures (2) and (3), *B* by itself and *C* by itself, on the 33rd day had not yet shown any rudiments whatever.

From the series of experiments just described, it would seem that *Coprinus niveus*, although homothallic, fruits much more vigorously in mixed cultures than in monosporous ones. This conclusion is an important one, for it seems to indicate that in a homothallic species when two mycelia in the diploid condition are allowed to unite, the compound mycelium resulting may fruit more vigorously than either of its components when separated. Is it possible that, when two diploid mycelia unite, the dicaryons may become rearranged so as to allow of sexual crossing? If so, we might conclude that crossed compound mycelia in *Coprinus niveus* fruit more vigorously than uncrossed or selfed mycelia, and we might appeal for an analogy to the results obtained by Charles Darwin in his experimental studies of cross-fertilisation and self-fertilisation in Flowering Plants. I regret that, up to the time of writing, I have not been able to repeat and extend the experiments which have just been described.

In *Coprinus sterquilinus* and *C. stercorarius* which, like *C. niveus*, are homothallic, a compound mycelium arising from many spores sown together did not appear to fruit any more vigorously or any sooner than monosporous mycelia grown under similar conditions. Hence we may conclude that, although in *Coprinus niveus* the mixing of the mycelia appears to increase the capacity for fruiting, yet this does not hold true for *C. sterquilinus* and *C. stercorarius*.

VII. Other smaller species.

Of *Coprinus ephemerus* Fr. three cultures were made, two monosporous and one polysporous, in dung tubes. All the three cultures produced fruit-body rudiments, but only the polysporous culture produced perfect fruit-bodies. Clamp-connections were found in the polysporous mycelium (Pl. VI, Fig. 12) but were not searched for in the monosporous mycelia.

Coprinus curtus Kalchb., *C. stellatus* Buller (a new and as yet undescribed species of the ephemerus group) and *C. cordisporus* Gibbs (a Canadian form of the species) were also investigated

for fruit-body production and for the development of clamp-connections. These three species appear to be entirely lacking in clamp-connections, for no clamp-connections were found even in their polysporous mycelia. All the septa dividing the mycelia into cells were perfectly simple transverse walls (Pl. VI, Figs. 13, 14, 15).

Of *Coprinus curtus* eight mycelia were isolated, six monosporous in origin and two polysporous. All the cultures produced fruit-body rudiments. The rudiments in the two polysporous cultures developed to maturity and the expanded fruit-bodies shed spores, but in none of the six monosporous cultures did the rudiments develop to the stage of spore-production. However, two of the monosporous cultures were sub-cultured on dung in large crystallising dishes. Both of them then produced numerous perfect fruit-bodies. We can, therefore, state that in *Coprinus curtus*, under favourable conditions, the monosporous mycelia are able to develop normal fruit-bodies.

Of *Coprinus stellatus* only two cultures were made, one monosporous in origin and the other polysporous, both in dung tubes. The polysporous culture produced normal fruit-bodies and the monosporous culture only fruit-body rudiments.

Of *Coprinus cordisporus* only two cultures were made, one monosporous and the other polysporous, both in dung tubes. Both cultures produced fruit-body rudiments, but in neither culture did any of the rudiments develop into perfect fruit-bodies.

VIII. *Coprinus comatus.*

The fruit-body of *Coprinus comatus* Fr., as Buller* has pointed out, has a mechanism for the production and liberation of its spores practically identical with that of *C. sterquilinus*; and the two species are undoubtedly closely related. It was hoped, therefore, that as *C. sterquilinus* fruits so readily in monosporous cultures, this would also happen with *C. comatus*. Both monosporous and polysporous mycelia of *C. comatus* were therefore isolated and transferred to large masses of sterilised horse-dung contained in crystallising dishes; but none of them ever fruited. A mycelium derived from a stipe was transferred to a large mass of sterilised horse-dung contained in a three-litre beaker, and covered with three inches of soil. The mycelium was in the secondary condition, for its hyphae showed an abundance of clamp-connections. It grew well, invaded the whole mass of the dung, and penetrated through the soil; but, for some reason or other, it failed to fruit. In *Coprinus comatus*, therefore, the non-production of fruit-bodies in the laboratory is common to

* A. H. R. Buller, *loc. cit.* pp. 306, 324.

both monosporous and polysporous mycelia; and, for the present, one cannot say whether or not the fruiting power of the mycelium is affected by its monosporous or polysporous mode of origin.

Polysporous mycelia of *Coprinus comatus* develop an abundance of clamp-connections but no clamp-connections could be observed in two monosporous mycelia. These two monosporous mycelia were cultivated for 90 days in dung tubes. Then portions of the mycelia were removed from the tubes and placed on agar plates. The mycelia grew well on the plates, but none of their hyphae developed clamp-connections. On the other hand, a mycelium derived from a stipe and placed on an agar plate under the same conditions as the monosporous mycelia, developed an abundance of clamp-connections. These observations indicate that *Coprinus comatus* is probably a heterothallic species. However, before this conclusion can be accepted as having been proved, some further experiments upon the mycelia, especially crossings, ought to be undertaken.

IX. Summary of data.

The following table summarises data for the nine species of Coprinus treated of in the foregoing pages.

Summary of Data for Species of Coprinus

Species	Number of monosporous cultures made	Presence or absence of clamp-connections in monosporous mycelia	Presence or absence of clamp-connections in polysporous mycelia	Presence or absence of oidia	Homothallic or heterothallic
C. sterquilinus	21	+	+	–	Homothallic
C. lagopus	12	+	+	+	,,
C. stercorarius	6	+	+	–	,,
C. niveus	5	+	+	+	,,
C. ephemerus	2	?	+	+	Not determined
C. curtus	6	–	–	+	,,
C. stellatus	1	–	–	+	,,
C. cordisporus	1	–	–	+	,,
C. comatus	2	–	+	?	Heterothallic
Total ...	56				

X. Discussion.

From the facts communicated in the foregoing pages, there seems to be no doubt that *Coprinus sterquilinus*, *C. lagopus*, *C. stercorarius*, and *C. niveus* are all homothallic; while, on the other hand, *C. comatus* appears to be heterothallic. Mlle Bensaude found that her *C. fimetarius* is heterothallic. Hence it appears that, in the genus Coprinus, some species are homothallic and others heterothallic.

Mlle Bensaude found that her *Coprinus fimetarius* was sterile in monosporous cultures and fertile only in cultures containing a compound mycelium formed by the anastomosis of her mycelium α and her mycelium β, which she presumed as a result of her investigations to be of opposite sex. In view of Kniep's discovery that in a heterothallic species even unmated haploid mycelia produce fruit-bodies, it is perhaps remarkable that Mlle Bensaude's monosporous cultures did not fruit at all. It is desirable that this absence of fruiting powers in monosporous mycelia should be confirmed by the study of more monosporous mycelia than two. It is possible that some monosporous mycelia of her species could be caused to fruit by continuing and extending their cultivation. However, apart from the supposed criterion of fertility and sterility, Mlle Bensaude has presented us with evidence which seems to prove conclusively that her *Coprinus fimetarius* is heterothallic; for she found that clamp-connections and dicaryons were never formed in connection with the monosporous mycelia, while they were always formed in compound mycelia resulting from the mixture of her mycelium α and her mycelium β.

Brefeld* in recording his pioneer work on the life-histories of the Basidiomycetes, stated that he obtained fruit-bodies from mycelia produced from single spores for the following species: *Coprinus stercorarius*, *C. lagopus*, *C. ephemerus*, and *C. ephemeroides*. Mlle Bensaude† has raised the question as to whether or not Brefeld's mycelia were truly monosporous. The material for my investigation has included the first three of Brefeld's species, and for these species my results have been identical with his. Thus Mlle Bensaude's question has been answered in Brefeld's favour.

Mlle Bensaude, as a matter of theory, considers that the oidia produced on the mycelium of her *C. fimetarius* may be sex-carriers, *i.e.* that a + oidium may unite with a − mycelium and thus produce a fertile secondary mycelium bearing clamp-connections and fruit-bodies; and *vice versa*. However, as we have seen, both *Coprinus lagopus* and *C. niveus* are both homothallic and yet they produce oidia. It seems clear, therefore, that the oidia of these two species cannot be considered to act as sex-carriers, at any rate under present-day conditions, for the mycelium is homothallic and such sex-carriers, therefore, would be superfluous.

Miss M. L. Baden‡ stated in 1915 that the spores of *Coprinus*

* O. Brefeld, Untersuchungen, Leipzig, Heft III, 1877.

† M. Bensaude, *loc. cit.* p. 108.

‡ M. L. Baden, Observations on the Germination of Spores of *Coprinus sterquilinus* Fr., Ann. of Bot., XXIV, 1915, p. 141.

sterquilinus can only germinate in the presence of bacteria. In 1911, A. H. R. Buller and S. G. Churchward, working in the Botanical Department of the University of Manitoba, carried out a series of experiments upon the conditions of germination for the spores of *C. sterquilinus*; and they found that Miss Baden's conclusion was incorrect, for in their experiments 80 to 90 per cent. of the spores germinated in perfectly sterile hanging drops of various media*. I herewith state that my investigations entirely confirm the work of Buller and Churchward, for the spores of *C. sterquilinus* used in my cultures, when germinating, never came into contact with any bacteria. Were the presence of bacteria a necessary condition for the germination of the spores of *C. sterquilinus*, the isolation of monosporous mycelia could not have been accomplished by the simple methods which I actually employed. In none of the nine species of Coprinus with which I worked, is the presence of bacteria a necessary condition for the germination of the spores.

Miss E. M. Wakefield† made monosporous cultures of *Schizophyllum commune* and of *Stereum purpureum* and came to the conclusion that the chief factor making for sterility or fertility in her cultures was individual mycelial peculiarity, some mycelia fruiting readily and others refusing to fruit under any conditions. According to Kniep, the explanation of Miss Wakefield's results is as follows. *Schizophyllum commune* is a heterothallic species which fruits readily when the mycelium is diploid and has clamp-connections but more or less reluctantly when the mycelium is haploid and has no clamp-connections. On pairing the 14 monosporous mycelia which he isolated, he found that some pairs yielded clamp-connections and fruit-bodies and others not. In my work on Coprinus, I did not obtain a heterothallic species which fruited in artificial culture. However, it is remarkable that the homothallic species *Coprinus niveus* exhibited individual peculiarity in the fruiting of its monosporous mycelia, some mycelia having fruited readily, others having produced only fruit-body rudiments, and one having produced no rudiments at all. Yet even here, as already described, fruiting appeared to be stimulated by mixing two mycelia.

* A. H. R. Buller and S. G. Churchward in an unpublished paper shown me by Professor Buller. The delay in publication has been caused by Churchward going overseas to the war. The details of the work will be given in Professor Buller's second volume of "Researches on Fungi" now in preparation for the Press.

† E. M. Wakefield, Die Bedingungen der Fruchtkörperbildung bei Hymenomyceten, sowie das Auftreten fertiler und steriler Stämme bei denselben, Naturw. Zeitschr. f. Forst- und Landwirtschaft, VII, 1909, pp. 521–550.

XI. Conclusions.

1. *Coprinus sterquilinus, C. lagopus, C. stercorarius, C. niveus, C. ephemerus, C. curtus, C. stellatus,* and *C. cordisporus* all produced rudimentary fruit-bodies on a mycelium which originated from a single spore. In *C. sterquilinus, C. lagopus, C. stercorarius, C. niveus,* and *C. curtus,* these fruit-body rudiments developed into perfect fruit-bodies which shed ripe spores. In *C. ephemerus, C. stellatus* and *C. cordisporus,* under the conditions of culture employed, the fruit-body rudiments remained as such and never developed into perfect fruit-bodies.

2. Both monosporous and polysporous mycelia of *Coprinus comatus* failed to produce fruit-bodies in dung cultures.

3. Brefeld's statement that fruit-bodies of *Coprinus stercorarius, C. lagopus,* and *C. ephemerus* are produced on a mycelium which has developed from a single spore, has been confirmed.

4. As determined by clamp-connection criteria, *Coprinus sterquilinus, C. lagopus, C. stercorarius,* and *C. niveus* are homothallic, and *C. comatus* heterothallic.

5. *Coprinus curtus, C. stellatus,* and *C. cordisporous* do not produce any clamp-connections on any of their mycelia whether of monosporous or of polysporous origin. It was therefore found impossible to decide by clamp-connection criteria whether these three species are homothallic or heterothallic.

6. *Coprinus sterquilinus* was successfully cultivated in pure monosporous cultures for five successive generations. The mycelium of the fifth generation was just as vigorous and fruited just as rapidly as the mycelium of the first generation. The cultivation of *C. sterquilinus* from mycelia of monosporous origin does not, therefore, appear to weaken the fungus in any way.

7. The spores of *Coprinus sterquilinus* germinate freely in perfectly sterile potato agar and dung agar. Incidentally, therefore, I find myself in agreement with Buller and Churchward who, in a paper as yet unpublished, state that the spores of *C. sterquilinus* germinate readily without the presence of bacteria.

8. The monosporous mycelia of *Coprinus niveus* which is homothallic, exhibit a considerable range of variability in their fruiting powers, some producing perfect fruit-bodies, others only fruit-body rudiments, and yet others no rudiments at all. The mixing of the monosporous mycelia in pairs was found to stimulate fruiting in a marked manner.

9. Both monosporous and polysporous mycelia of *Coprinus lagopus,* when grown on large dung masses in crystallising

dishes, give rise to fruit-bodies some of which are perfect but others of which produce many spores which never ripen, a few ripe spores only, or no spores at all. Since this imperfection in spore-production is common to fruit-bodies produced by mycelia of both monosporous and polysporous origin, it cannot be due to sex.

10. Since *Coprinus lagopus* and *C. niveus* are both homothallic and yet produce oidia, Mlle Bensaude's interpretation of oidia as sex-carriers seems to be of doubtful value.

The investigations recorded above were made in the Botanical Department of the University of Manitoba during the tenure of a Studentship granted by the Canadian Honorary Advisory Council for Scientific and Industrial Research. In conclusion, I wish to express my indebtedness to Professor A. H. R. Buller for suggesting the investigation and for continuous help and encouragement during the progress of the work.

DESCRIPTION OF THE ILLUSTRATIONS.

Plate VI.

The magnification for Figures 1 and 2 is 510, and that for the remaining figures 480.

Fig. 1. *Coprinus sterquilinus*. A germinating spore after 17 hours in a potato decoction.

Fig. 2. *Coprinus sterquilinus*. Another germinating spore after 21 hours in a potato decoction.

Fig. 3. *Coprinus sterquilinus*. Two hyphae showing clamp-connections. From a compound mycelium of polysporous origin derived from the spores of a fruit-body of monosporous origin.

Fig. 4. *Coprinus sterquilinus*. A branched hypha showing one perfect clamp-connection and another clamp-connection in course of formation. From a monosporous mycelium of the fifth successive generation.

Fig. 5. *Coprinus lagopus*. A germinating spore after 18 hours in a dung-gelatine culture medium.

Figs. 6 and 7. *Coprinus lagopus*. Hyphae showing clamp-connections. Both from a monosporous mycelium derived from the spore of a wild fruit-body.

Fig. 8. *Coprinus lagopus*. A branched hypha showing a clamp-connection. From a compound mycelium of polysporous origin derived from the spores of a fruit-body of monosporous origin.

Fig. 9. *Coprinus stercorarius*. A branched hypha showing two small clamp-connections. From a compound mycelium of polysporous origin derived from the spores of a fruit-body of monosporous origin.

Fig. 10. *Coprinus niveus*. A germinating spore, taken from a fruit-body of monosporous origin, after 18 hours in dung-gelatine.

Fig. 11. *Coprinus niveus*. A branched hypha showing two clamp-connections. From a compound mycelium of polysporous origin derived from the spores of a fruit-body of monosporous origin.

Fig. 12. *Coprinus ephemerus* (a purplish form). A branched hypha showing two perfect clamp-connections and one clamp-connection in course of development. From a compound mycelium derived from the spores of a wild fruit-body.

Fig. 13. *Coprinus curtus*. A hypha showing three simple septa. From a monosporous mycelium derived from a spore of a wild fruit-body. The mycelium had been growing for 19 days.

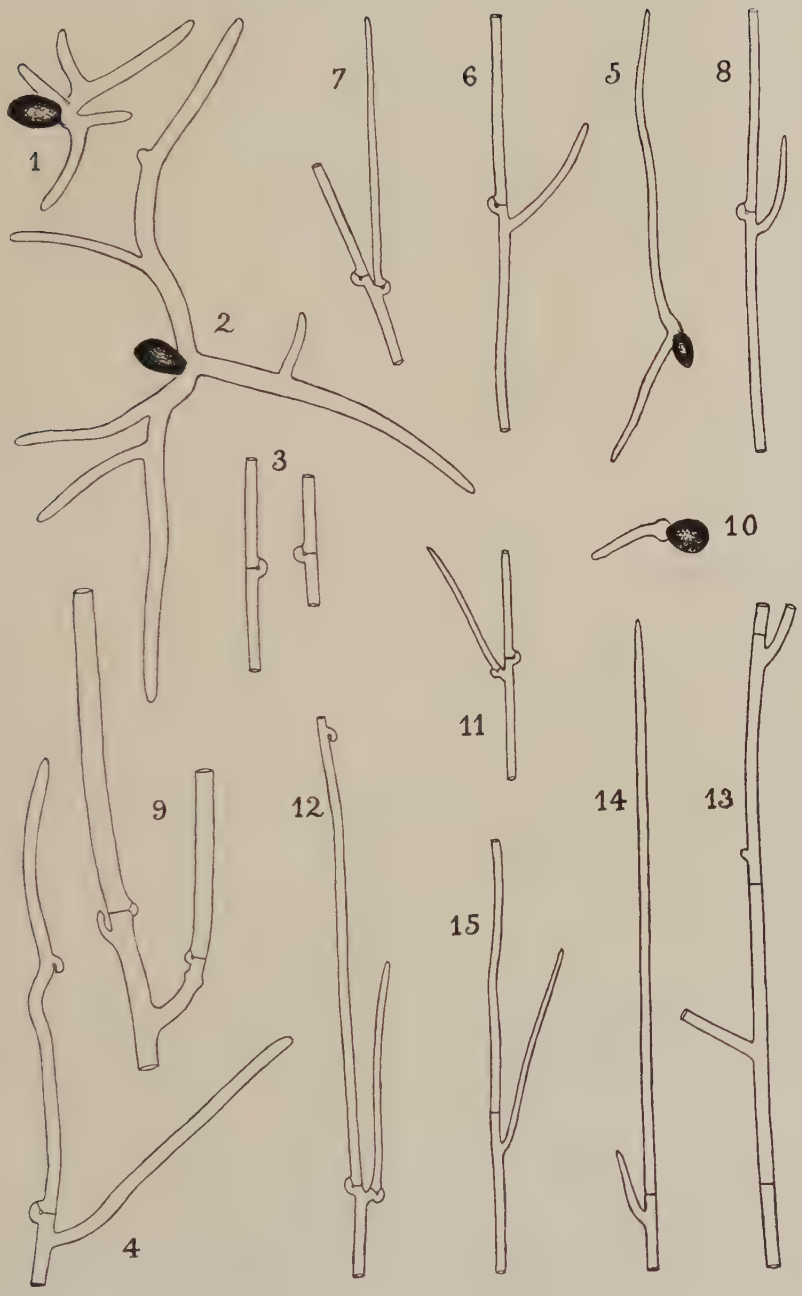
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Fig. 14. *Coprinus stellatus*. A branched hypha showing a simple septum. From a compound mycelium of polysporous origin, the spores having been derived from a wild fruit-body.

Fig. 15. *Coprinus cordisporus*. A branched hypha showing a simple septum. From a compound mycelium of polysporous origin, the spores having been derived from a wild fruit-body.

PLATE VII.

Fig. 1. *Coprinus sterquilinus*. Two horse-dung cultures from which fruit-bodies have been developed, made simultaneously. The cotton-wool plugs were removed 48 hours ago to allow the fruit-bodies to elongate without being injured. The culture tube on the left contains a mycelium of monosporous origin. This mycelium has just given rise to its first fruit-body with its spores which completes the last of a series of five successive generations of monosporous cultures. The culture tube on the right contains a compound mycelium of polysporous origin derived from spores of the same fruit-body as that which provided the spore for the culture already described. This compound mycelium has given rise to a fruit-body which expanded, shed spores, and exhausted itself on the day before the photograph was taken. Seven-tenths natural size.

Fig. 2. *Coprinus lagopus*. Photograph of a group of fruit-bodies which has come up on sterilised horse-dung contained in a large crystallising dish. The mycelium was of monosporous origin and the original spore was derived from a wild fruit-body. The mycelium was transferred to the culture medium only 12 days before the photograph was taken. The pilei are covered with characteristic loose white scales and are ripening their spores in preparation for the elongation of the stipes and pilear expansion. Natural size.

NOTES.

LONGEVITY OF SPORES OF A FUNGUS IN A MUSEUM SPECIMEN.

For comparison with a fungus which had been isolated from and proved to be the cause of black spots on leather, a small portion of a piece of the bark of a lime tree covered with a black sooty deposit, was given to me from the Herbarium of the British Museum (Natural History) in June of this year.

The specimen was from the Rabenhorst-Klotschii, Herbarium vivum Mycologicum, Editio II, Series I, No. 75, and was described as *Cladosporium fumago* Lk. It had been obtained from Sächs, Switzerland, in the summer of 1854. The cabinets in which the specimen had been kept in the Museum are saturated with camphor. Small portions of the bark were placed on slopes of Beer Wort Agar, Czapek's and other media and incubated for some days without showing any signs of life. A piece placed in a tube of sterile Beer Wort also showed no signs of growth.

The following technique was however successful:

A tube of sterile Beer Wort was kept in a slanting position, a small piece of the bark was introduced, dipped under the

surface of the liquid by means of a sterile platinum wire loop, and withdrawn on to the side of the glass tube, where it was left exposed to the air inside the tube for 24 hours. It was then dipped under the surface of the wort, and again withdrawn and left for 24 hours, the tube being incubated at 25° C. in the sloping position. This treatment was continued for five days, the piece of bark being dipped and withdrawn every morning.

At the end of this time signs of growth began to appear, and by the seventh day, sufficient mycelium had formed to enable sub-cultures to be made.

The fungus then grew quite readily on ordinary Beer Wort Agar or Czapek's medium, and was easily identified as *Fumago vagans* Pers. (= *Cladosporium fumago* Lk.).

During the cultivation process, no other organism made its appearance.

This seems to be of interest as a case of the persistance of life in the spores or mycelium of a Hyphomycete kept as a museum specimen for 67 years.

R. LESLIE COLLETT,
(British Leather Manufacturers' Research Association).

ERROR IN BOUDIER'S MICROMETRIC MEASUREMENTS.

Monsieur René Maire makes the following very important statement regarding Boudier's measurements of spores in the Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord, VIII, no. 9 (Dec. 1917), 247: "Les mensurations de Boudier étant d'ordinaire trop fortes d'1/10 environ, par suite d'une erreur dans la confection de son échelle micrométrique."

CARLETON REA.

Published the 13th December, 1921.

REVIEW.

A Handbook of the British Lichens, by ANNIE LORRAIN SMITH. 8vo. 158 pp. with 90 figs. in the text. 6*s*. cloth. London. Printed by order of the Trustees of the British Museum.

To students of Bryology the identification of specimens is made easy by the keys given in the excellent works of Dixon and Macvicar. In the *Monograph of the British Lichens* by Miss Lorrain Smith no such keys are given and much difficulty is encountered by a beginner in running down a species in large genera such as Lecanora and Lecidea. This deficiency (if such it can be considered in a monograph) has now been remedied by the publication of the present *Handbook*. The author has placed lichenologists of all classes under further obligation by producing a condensed volume which can easily be carried in the pocket.

There is an introduction of thirteen pages (with many illustrations) giving a short account of the lichen plant and dealing with such matters as constitution, morphology, peculiar vegetative structures, reproductive organs, physiology, ecology and distribution, economic uses, phylogeny and classification. This is followed by a list of abbreviations used in the descriptions. In the body of the work the arrangement down to the families is like that in the author's larger book. Following the description of the family there is a key to the genera. The keys are not of a dichotomous type but of the group type, one much to be preferred in that it ensures that genera (and species) of close affinity do not get widely separated. The genera are described and in the majority of cases a drawing is given mostly from the plates in the *Monograph*. In the keys to the species the grouping is made on prominent characters of habit, habitat or growth form and in most of the smaller genera the morphological characters are sufficient for an identification in the field: in the larger genera recourse often has to be had to reactions and microscopic characters. There is a glossary and a workable index. The *Handbook* is invaluable for what it sets out to be—a key to the British species and a portable guide.

H. H. K.

PROCEEDINGS, 1921.

MEETING. UNIVERSITY COLLEGE, LONDON. *Jan. 22nd.*

Mr F. T. Brooks. Investigations on some tomato fruit diseases.
Dr E. J. Butler. The Imperial Bureau of Mycology.
Miss G. Lister. A new genus of Mycetozoa.
Mr T. Petch. Thread Blights.
Mr J. Ramsbottom. Orchid culture.

MEETING. UNIVERSITY COLLEGE, LONDON. *March 19th.*

Dr R. St John Brooks. National Collection of Type Cultures.
Dr W. Brown. Studies in the physiology of parasitism.
Mr A. D. Cotton. The Ministry of Agriculture's plant disease survey.
Dr P. Haas. Carrageen as a culture medium.
Dr A. S. Horne. A pleomorphic Aposphaeria.
Mr R. Paulson. *Protococcus* as the gonidium of a Lichen.
Miss A. Lorrain Smith. The lichen as transmigrant.